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FINAL REPORT

W-95-R(SI)-6

ECOLOGY OF CANADA GEESE: SOUTHERN ILLINOIS WINTERING GROUNDS, FLYWAY ROUTES, AND BREEDING GROUND UTILIZATION

Submitted by:

Cooperative Wildlife Research Laboratory, SIU-C

Presented to:

Illinois Department of Conservation

September, 1989

Prepared by:
Thomas C. Tacha

Thomas C. Tacha, Assistant Professor
Cooperative Wildlife Research Lab.
Southern Illinois University
Carbondale, IL 62901

Approved by:

Alan Woolf, Director
Cooperative Wildlife Research Lab.
Southern Illinois University
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FINAL REPORT

STATE OF ILLINOIS

W-95-R(SI)

Project Period: October 1, 1983 through June 30, 1989

Study Title: Ecology of Canada geese: southern Illinois wintering grounds, flyway routes, and breeding ground utilization

Prepared by Thomas C. Tacha
Cooperative Wildlife Research Laboratory
Southern Illinois University at Carbondale

Need:

Personnel of state and federal agencies, researchers, and hunting groups maintain different interests and opinions about the role of the southern Illinois region in management of the Mississippi Valley Population of Canada geese (*Branta canadensis*). Available data and their interpretations vary with regard to annual population levels and harvests in southern Illinois, length of hunting seasons and impact of quota zones, fall and winter goose movements, origin and migration patterns of the geese, and annual reproduction. Research was needed to address these issues and to provide information allowing improved management of this economically important resource.

Objective:

To (1) gain a more precise understanding of the early and late flight phenomenon as this is related to goose distribution among southern Illinois refuges as well as their continuity of use; and dispersal/egress during wintering either laterally or longitudinally; any relationships of winter movements with food supply, weather, hunting, etc.; (2) develop a more precise analysis of patterns of movement to and from breeding grounds with special emphasis on the impact of staging areas on the southern Illinois wintering population; (3) delineate more precisely the nesting grounds of the southern Illinois geese and contribute better insight into this population's annual breeding breeding and reproduction; and (4) develop a better understanding of the role of southern Illinois refuges as reflected in patterns of goose use of individual refuges September to March.

EXECUTIVE SUMMARY

Status

This project began October 1, 1983 with 7 Jobs. Job V (Nesting grounds in Canada of Canada geese that winter in southern Illinois) was completed and a Final Report submitted in October, 1987. Jobs I-IV and VI were completed this segment; findings and recommendations of these Jobs are presented in this Final Report in accordance with requirements of Job VII (Analysis and Report). Only the abstract and recommendations for Job VI (Role of southern Illinois refuges in contributing needs of Canada geese September - March) are included in the body of this report; the entire Final Report for Job VI is appended in the form of 2 Ph.D. Dissertations that were submitted in partial fulfillment of the requirements for Doctor of Philosophy degrees in Zoology at SIUC. The following summary includes findings and recommendations from all Jobs (including Job V) in order to present a more complete synopsis of the project.

Population Management

Aerial surveys were conducted to locate radio-marked Canada geese (Branta canadensis interior) during May-June, 1984-86 throughout the presumed breeding grounds of the Mississippi Valley Population (MVP). Based on 84 adult females located, 84 ± 8(SE)% nested within 80 km of the Hudson and James Bay coasts. The observed coastal distribution of nesting geese verified the coast of Hudson Bay in Ontario as a representative site for current productivity surveys, and banding and breeding biology studies.

Similarity of breeding ground distributions suggest geese in the MVP associated with fall staging in Wisconsin and southern Illinois, specific refuges in southern Illinois, or roosting sites within refuges, do not constitute subpopulations with discrete breeding distributions. In addition, no significant cross-seasonal or annual homing tendency was found between early or late migrants or among geese that spent the fall at various southern Illinois refuges. These results suggest individual geese of the MVP fall stage primarily in response to overall goose distribution, and not on the basis of site fidelity. Lack of association between breeding distribution and previously identified segments of the MVP, combined with low cross-seasonal and annual fidelity of individual geese to regional or local sites during fall hunting seasons, casts serious doubts on the existence of manageable subpopulations (genotypic groups) or segments (traditional groups) within the MVP that uses Wisconsin or Illinois. Harvest regulations, inventory, and other management activities can and should vary between states and/or areas within states as needed, but differential management should be primarily in response to spatial and temporal variation in distribution and abundance of birds. The lack of manageable subgroups emphasizes the need for integrated management of the MVP as a whole; priority should be given to managing cumulative impacts of harvest at all MVP locations.

Aerial surveys to locate radio-marked geese indicated fall and spring migration was concentrated in a relatively narrow corridor in central Illinois and southeastern Wisconsin. A major spring staging area in the Kaskaskia River Valley north of Carlyle Lake in central Illinois was identified. Appropriate private, state, and/or federal agencies should continue to protect and/or enhance roosting and feeding habitat for spring migrating geese at major staging areas in Illinois and Wisconsin. The Kaskaskia River Valley between Carlyle and Shelbyville lakes in Illinois is virtually unprotected and unmanaged; improvements should concentrate on the area between the Carlyle Lake subimpoundments and the city of Vandalia.

Chronology of early spring migration varied annually, but timing of major departure from Wisconsin staging areas and arrival on nesting areas in Ontario was consistent. Chronology of fall migration also varied annually, and timing of movements of birds from Wisconsin to southern Illinois caused underestimates in midwinter population inventories (conducted mid-December) in 3 of 5 years. The midwinter inventory of the MVP should be conducted in the second week of January when fall migration is complete and birds are most concentrated. Current inventories are too inaccurate and imprecise to serve as reliable population estimates, or an index.

Fall and winter distributions of MVP geese in the southern Illinois area generally remained stable 1983-89 despite a nearly 3-fold increase in winter goose use. However, goose use of Horseshoe Lake Refuge in winter increased dramatically in 1988-89. Fall distribution will probably remain similar for some time to come, but winter distribution may change with increased goose use of Horseshoe Lake Refuge.

Distributions of geese among southern Illinois refuges were generally poorly associated with quantity and quality of habitat. However, distribution and movement information are both consistent with the hypothesis that the primary factor influencing winter distribution of MVP geese in southern Illinois is a strong traditional use of the Mississippi River Valley in general and Horseshoe Lake in particular.

Evidence indicates a strong tendency for geese fall staging in southern Illinois to move south and west and end up wintering at Horseshoe Lake and Union County refuges. Low rates of long-term movement away from these refuges emphasizes their importance as primary wintering areas. Thus, management of these areas should emphasize providing adequate quantity and quality habitat for wintering geese (December-February).

Most geese present at Crab Orchard, Rend Lake, and Ballard County refuges leave before the end of winter. Crab Orchard and Rend Lake refuges appear to function as terminal staging areas for fall-migrating geese, especially early migrants. Ballard County appears to function primarily as a way-station for geese moving south from Crab Orchard and Rend Lake, and for short-term movements (leave and return within 8 days) of geese from Horseshoe Lake. Distribution and movements data both lead to the suggestion that Crab Orchard, Rend Lake, and (later on in January) Ballard County refuges be managed primarily (but not exclusively) for fall goose use and hunting recreation (October-December).

Habitat Management

Habitat Use and Energetics Investigations. - Habitat and refuge use of wintering and migrating MVP geese were studied October-February 1984-1987 at Union County Conservation Area (CA) and Rend Lake in southern Illinois and

October-December and March-April 1984-1986 at Horicon National Wildlife Refuge (NWR) in Wisconsin. Habitat and refuge use were quantified by driving survey routes representative of available habitats. Use of refuges increased during hunting seasons at southern Illinois study areas, but did not at Horicon NWR. Habitat use varied among seasons and locations. Use of winter wheat and alfalfa/clover habitats was highest in fall, use of lakes was highest in winter, and use of lowland pastures was highest in spring. Shallow wetlands and corn fields were used more at Horicon NWR, while winter wheat and soybean fields were used more at southern Illinois study areas.

Habitat management on Union County and Rend Lake refuges has large potential for affecting geese because refuge use was consistently high. Lake, shallow wetland, and alfalfa/clover habitats should be developed and/or increased on both refuges.

Soybean habitat was abundant on private land and need not be made available to geese on Union County or Rend Lake refuges. However, soybeans are valuable for agricultural field management (Johnson grass [*Sorghum halepense*] control and nitrogen fixation), and are suitable to precede a second crop of winter wheat. If sunflowers are desired, fields can be managed to produce a double-crop of sunflowers followed by winter wheat.

Winter wheat and other forage (mostly fescue) availability on Union County and Rend Lake refuges should remain at levels observed during this study. These forage foods provide nutrients not supplied by corn.

Milo probably will continue to be available on private lands and should not be emphasized when managing for geese at Union County or Rend Lake refuges. Milo had both low use and low selection at southern Illinois refuges.

Estimates of time and energy allocations for populations at Union County Refuge and Horicon NWR were developed from activity estimates of flocks observed during habitat use surveys. Total energy available on and within 16 km of both refuges was estimated from land use inventories and food sampling within agricultural habitats. Activities varied among habitats; resting was the most common activity on lakes and feeding was most common in upland habitats. Energy needs ranged from 509-926 kcal/goose/day. Available energy resources did not appear adequate on Union County Refuge during hunting season in 1 of 3 years (1986-87). Adequate energy was available during all seasons within 16 km of both refuges.

Geese responded to hunting differently in southern Illinois than in Wisconsin, probably because hunting was more intense in southern Illinois. During hunting, geese at Horicon NWR did not increase their use of the refuge while geese in southern Illinois were functionally restricted to the refuge. Apparently, the risk of mortality outweighed the potential benefits of feeding off-refuge in southern Illinois. The reverse was true near Horicon NWR; benefits of feeding off-refuge outweighed increased risks of mortality.

Energy availability should meet or exceed population energy needs if a management goal is to maintain geese in the best possible condition. Restriction of geese to Union County Refuge during hunting season increases the potential impact of inadequate energy availability on the refuge during hunting. The timing of hunting season influences population energy needs during hunting. Long seasons lead to greater refuge goose-day-use and energy needs than short seasons. Seasons that continue after arrival of late migrants lead to higher average daily population sizes and energy needs than seasons ending before arrival of late migrants. The least energetically demanding season would be short and early, but this could lead to difficulties in meeting harvest objectives. Increasing the daily bag limit above the current 2 geese per day would likely increase the average daily kill and thus permit a shorter season while still meeting harvest objectives.

Maximum energy resources can be provided during hunting season by harvesting more corn during this period. However, an increase in the proportion of corn fields combined causes a decrease in the proportion that can be mowed after hunting. Since mowing makes more food available than combining, the net result of increased combining is lower energy available after hunting. The effect of reduced energy available after hunting is unknown; geese may 1) compensate by exploiting more off-refuge resources, 2) disperse to other areas, and/or 3) reduce energy intake. Details on the optimal timing of corn harvest require further investigation.

Horicon NWR in Wisconsin should continue to emphasize wetland management. Shallow wetland habitat was important but may be inadequately available in the Horicon NWR area. State or federal agencies should consider measures to protect small wetlands and associated lowland pastures to the north and west of Horicon NWR. These habitat complexes were important in spring when geese acquired body reserves important for reproduction.

Agricultural habitat currently need not be developed on Horicon NWR. All important agricultural habitats were adequately available on private land. However, extensive fall plowing should be actively discouraged when possible.

Dairy farming should be encouraged near Horicon NWR. Resource availability near Horicon NWR is strongly affected by dairy farming. Lowland pasture, alfalfa, high moisture corn, and spread manure are all components of dairy farming and also important to geese. Reduction in dairy farming could negatively impact the goose resource.

Goose Distribution and Movements Investigations. - Comparisons of distributions of geese and habitats among southern Illinois refuges, analyses of fall and winter movements, and results of local habitat use and energetics studies all indicate a serious problem of limited food resources in winter is evolving at Horseshoe Lake and (to a lesser extent) Union County refuges. Present goose use (1989) exceeds available food resources, and the problem will probably worsen until food resource availability is dramatically improved via increasing cropland acreage (refuge size) and/or more efficient (for maximizing food energy production) crop management. Maximum effort should be expended to improve the quantity and quality of habitat at Horseshoe Lake and Union County refuges and/or to reduce goose use of these areas via population reduction.

Distribution and movements also identified several locations that are important to geese, but that are not currently protected adequately. The Campbell's Pond area was by far the most important of these. Current IDOC efforts to protect and enhance this area should continue. Other such areas of relative import are the Cache River bottoms near Interstate Highway 57 and the Will Scarlett mine near Harrisburg.

Tripling goose use of southern Illinois refuges leads to the recommendation that at least one additional refuge, or large-scale expansion of existing refuges, is needed. First and foremost is the need for additional refuge land area to support food resources for geese in late fall and winter. Based on distribution and movements in the past, a new or greatly expanded refuge is needed in the Mississippi River Valley near Horseshoe Lake. Priority should be given to land acquisition and improved land management on existing lands in the area. Recent increases in winter use of the Cache River bottoms suggest a refuge including this area could be beneficial. Current efforts to establish a refuge complex in this area are encouraged; these efforts should consider providing habitat, including croplands and open roosting water, for wintering Canada geese.

Basic Ecology

Habitat Use and Time and Energy. - Habitat use, behavior and energy strategies of MVP Canada geese were variable, allowing them to adapt to a wide range of environmental conditions throughout their annual cycle and various life stages. Geese relied extensively on agricultural habitats for meeting nutritional needs during migration and wintering. However, habitat use differed among locations, years, and seasons, indicating considerable flexibility. Variation in habitat use was related to dynamic environmental conditions, habitat availability, and goose nutritional needs.

Environmental conditions affected habitat use, and habitat use affected behavior and energy strategies. Geese increased their use of lakes with colder temperatures. The use of lakes led to minimal energy expenditures and intake as geese spent approximately 75% of their time resting and <5% of their time feeding. In warmer temperatures the use of upland habitats increased. This was associated with increased energy expenditures and intake as geese fed and rested approximately 50 and 30% of their time, respectively.

Behavior and energy expenditures also varied as geese matured and passed through life stages. Variations in behavior and energy expenditures appeared to have adaptive values that enhanced survival and/or reproduction. A hypothetical "typical" goose assumed 4 distinct social classes during its life: juvenile in family, single adult, paired adult, and parent adult.

Parental vigilance allowed juveniles to feed as much or more than any other social class. Extensive feeding was necessary for juveniles to obtain nutrients needed for rapid growth and development. By the time goslings were

90 days old, feathers and muscles were sufficiently developed to allow migratory flight. Extensive feeding continued during fall and winter and this allowed juveniles to store energy that could enhance survival during extended periods of cold.

Most geese disassociate from their parents when they are about 1 year old. Singles no longer benefitted from parental care and compensated by increasing their alert behavior. Alert behavior probably functioned to locate food as well as predators.

Pairing generally occurs when geese are 2-3 years old. Pair bond maintenance appeared responsible for increased alert behavior and decreased feeding. These behavioral costs may have been balanced by increased dominance that allowed paired geese to access preferred feeding and/or resting locations.

Care of juveniles led to further behavioral changes. Parents sacrificed feeding and/or resting time to care for juveniles by maintaining increased vigilance. This was not immediately advantageous to parents but probably enhanced juvenile survival and the parents' personal fitness. Also, dominance increases with larger social groups and this may offset some costs of parental care.

Total behavioral costs of parental care were shared by both parents during an entire annual cycle but relative costs to each sex varied among seasons. Costs to females were higher during incubation but costs to males were higher during other seasons. Theory contends that the need for extended biparental care has led to the evolution of monogamy and sharing of parental costs; this ultimately allows greater offspring survivorship or quality.

Physiological Condition and Nutrition. - Body composition (lipid and protein reserves) was one of several behavioral and physiological parameters

MVP geese used to balance seasonal changes in nutrient availability and demand. MVP geese accumulated nutrient reserves between the end of nesting and fall migration (June-September), after fall migration before the onset of inclement winter weather (October-December), and during spring migration before arrival on nesting areas (March-April). Nutrient reserves were catabolized during winter (December-February) and late spring (April-May) when foraging activity may have been limited by energetic constraints and/or food availability.

Breeding males and females had their lowest levels of body, lipid, and protein reserves at the end of incubation. Lipid and protein reserves generally increased in all age, sex and social groups from incubation through late fall or early winter; however, temporary lipid declines associated with fall migration occurred in adults.

Wing and body-molts were initiated in northern Ontario, 2 months before fall migration, but were completed on fall and winter use areas over a period of 6 months. Negative impacts of molting on body condition were not observed, although annual and geographic variation in molt intensity was modestly associated with differences in lipid masses. The association was positive, suggesting greater molt intensity and more rapid feather replacement in years and locations where more productive energy was available to support simultaneous lipid deposition and completion of molting. Molt patterns of Canada geese appear to have evolved with inherent flexibility that allows geese to minimize nutritional conflicts between molting and other essential maintenance and productive processes. The simple molt patterns of Canada geese allow nutritional costs of feather replacement to be spread over long time periods.

Late migrant adults, remaining in Wisconsin through fall consumed larger proportions of corn, and deposited greater lipid reserves, than early migrant adults migrating directly to southern Illinois. Fall-winter nutritional tactics of early and late migrants were adjusted in response to differences in environmental conditions, hunting pressure, and food availability that each group experienced during fall. Late migrants emphasized energy acquisition in fall, and minimized energy expenditures in winter. Lipid and protein reserves were catabolized by late migrants as an alternative to sustained foraging efforts that could have maintained constant levels of nutritional reserves in late winter. Early migrants deposited lipid reserves before hunting seasons, apparently sustaining foraging efforts that maintained energy reserves at relatively constant levels from late fall through winter.

Seasonal, annual, and geographic differences in body composition were highly associated with changes in diet composition. Close relationships between diet and body composition were most evident in comparisons involving early and late migrants during fall. Composite diets with high levels of apparent metabolizable energy promoted lipid deposition, but provided lower levels of protein. Lower energy diets were more diverse, generally including items with relatively high protein content. Geese spent more time feeding when they were consuming lower energy diets, but apparently not enough to allow deposition of similar lipid quantities that occurred on high energy diets.

Juvenile and yearling geese were physically immature, having smaller protein reserves, muscle masses, and structural size than older age classes through fall and winter. Lipid reserves of these younger geese were unaffected by their immaturity, and there was evidence of more favorable body condition than in older geese, especially in winter and early spring.

Unpaired geese also had smaller protein and muscle masses and structural size than paired geese. These differences were mostly attributable to age, since the exclusion of yearlings from samples of unpaired geese narrowed differences between paired and unpaired birds. Parent females maintained increasingly smaller lipid reserves than paired females through winter and early spring migration, while juveniles increased lipid and protein masses.

Early and late migrants left southern Illinois in February with larger lipid and similar protein reserves compared to when they arrived on fall use areas in October. Large increases in lipid and protein reserves occurred between February and April as geese migrated through central and northern Illinois and east-central Wisconsin. Adult males and females gained >70% of lipid reserves acquired in spring during 4-5 weeks in east-central Wisconsin. Adult males acquired most of their spring protein reserves in east-central Wisconsin, but protein reserves of females increased most as they migrated through central and Northern Illinois. Most deposition of lipid and protein reserves by juveniles in spring occurred before they arrived in Wisconsin.

Parent females acquired the largest lipid masses among all age, sex, and social groups during spring migration. This apparently occurred at the expense of their mates, as parent males traded feeding time for maintaining vigilance over their family, gaining the smallest lipid reserves of any adult sex/social group. The disparity in protein reserves between paired and unpaired adults increased between February and April, as paired geese deposited larger protein masses. Paired females departed for nesting areas with larger lipid reserves than unpaired females, but no difference associated with pair status occurred within. Juveniles acquired the smallest nutrient reserves among all age and social groups during spring migration.

Lipid and protein reserves deposited during spring migration were obtained with diversely composed diets of intermediate energy density. By increasing daily dry matter intake above winter levels geese were able to deposit large nutrient reserves despite lower dietary energy content.

Most of the nutrient reserves acquired by MVP geese during spring migration were catabolized during prenesting. All age/sex/social groups lost lipid reserves between arriving on nesting areas near the Hudson Bay coast, and the start of egg-laying. The smallest losses were sustained by females that underwent rapid follicle development. These nesting females were also the only geese that did not lose protein reserves during prenesting. Juveniles sustained the smallest lipid losses during prenesting, but still maintained smaller lipid masses than adults. The only time that paired males had larger lipid masses than unpaired males was at the end of prenesting. No differences in lipid masses occurred between paired and unpaired females during prenesting; however, unpaired adults continued with smaller protein reserves than paired adults in both sexes.

Food intake during long prenesting intervals in coastal areas of the Hudson Bay Lowlands appeared essential to maintain adequate nutrient reserves for successful reproduction. Endogenous lipids supplied material for yolk formation and energy during egg-laying, allowing geese to forage for protein and minerals that were incorporated into eggs from dietary sources, as well as mobilized from stored reserves. Males catabolized lipid reserves at a constant rate through prenesting and incubation. Protein reserves of paired males were stable during incubation as food intake supplied most of their daily requirements. Females fed little during incubation when lipid and protein catabolism supplied at least 75% of energy requirements.

Job I. Early and Late Migration Phenomenon of Canada Geese that Winter in Southern Illinois

Objective: To develop a more precise understanding of the early and late flight patterns of Canada geese migrating to southern Illinois; and, to relate this phenomenon to initial goose distribution among southern Illinois refuges.

INTRODUCTION

This Job summarizes banding and recovery information for the project, and provides information about integrity of segments of the MVP via analyses of annual fall homing to Wisconsin vs. southern Illinois, and among representative refuges in southern Illinois. Tacha et al. (1988) concluded geese that spent the fall in Wisconsin and southern Illinois did not use different parts of the MVP breeding range, and suggested these groups may not constitute manageable subpopulations of the MVP. High fidelity to fall use areas could make selective management of segments of the MVP at migration stopovers or wintering areas productive (Craven and Rusch 1983), even if these aggregations of geese do not constitute subpopulations occupying distinct areas within the general MVP breeding range (Tacha et al. 1988).

W. D. Klimstra, D. D. Thornburg, and A. Woolf provided assistance throughout the study. Personnel from the Moosonee District of the Ontario Ministry of Natural Resources, Horicon National Wildlife Refuge (NWR), Crab Orchard NWR, and Union County Refuge assisted with trapping and banding efforts. D. H. Rusch and other staff of the Wisconsin Cooperative Wildlife Research Unit shared information on sightings of radio-marked geese. K. F. Abraham, D. F. Caithamer, R. J. Gates, C. R. Paine, R. D. Pritchert, J. W. Spitzkeit, and R. W. Whitton provided valuable field assistance.

METHODS

Definitions

Fall and spring staging areas were locations where birds stopped for any length of time during fall or spring migration. Wintering areas were locations where birds spent >50% of their time between fall and spring migration.

Some geese of the MVP migrate directly to wintering areas in southern Illinois during September-November (early migrants), while others (late migrants) stay in Wisconsin from September until December-January before finishing fall migration to wintering areas in southern Illinois (Kennedy and Arthur 1974). Fall is defined as from when geese leave breeding areas (usually September) until 21 December (winter solstice), and winter as 22 December until first northern movements of geese out of southern Illinois occur (February in most years). Thus, some refuges in southern Illinois may serve early migrants as fall use areas in fall, and wintering areas in winter.

Radio-marking and Recovery

A total of 534 adult female Canada geese were marked with standard aluminum leg bands, serially numbered plastic neck bands, and radio transmitters with a 12-14 month life span during fall 1983-88 (Table 1). Radios were mounted on neck bands in 1983 and backpacks were used 1984-88. Females with open oviducts and other cloacal characteristics indicative of after-second-year geese (Hanson 1967) were used to minimize the probability of 2 members of a pair or family unit being marked. Although some authors include both interior (_B_. _c_. _interior_) and giant (_B_. _c_. _maxima_) subspecies in the MVP (see Bellrose 1980:248), giant Canada geese were identified using measurements obtained during banding (after Spitzkeit and Tacha 1986) and excluded from our study.

To facilitate recovery of radios, neck collars were labeled with a request that, if found, please call collect the Cooperative Wildlife Research Laboratory. Provincial and state agencies of the Mississippi Flyway and the Southern Illinois Quota Zone Waterfowl Association (SIQWA) were advised of the need to recover radios from harvested geese, and agreed to cooperate in recovery procedures. SIQWA provided $25 rewards for returned radios that were refurbished and used in subsequent bandings.

We generally monitored radio-marked geese in wintering areas twice/week via aerial surveys during October-February, 1983-89 and once/2 weeks in Wisconsin October-November, 1984-87 (see Job IV methods). Geese located repeatedly in the same area were checked via ground monitoring. A final aerial survey and follow-up ground checks conducted in April after geese departed allowed further radio recoveries. All radios recovered were considered to have been lost by the goose, or "found dead" if the radio was attached to a carcass, unless reported as shot by hunters. Reporting rates of hunters were unknown, but probably high due to the reward offered.

Fall Homing

Geese marked in October 1984-87 at Horicon NWR in Wisconsin ($\underline{n}$=75) represented late migrants to southern Illinois (Kennedy and Arthur 1974). Birds marked during October and early November 1983-87 ($\underline{n}$=91) in southern Illinois represented early migrants; an additional 52 geese of unknown migration status (early vs. late) were marked in January 1984-86 at Rend Lake, Illinois. Another 39 adult females with brood patches were trapped from flocks with goslings and marked in late July 1986 at 4 locations along the Hudson Bay coast of Ontario (approximately evenly spaced from Cape Henrietta Maria to the Manitoba border); 25 of these geese were subsequently located

October-November in southeastern Wisconsin and also served as a sample of late migrants in 1986 (total n=100 for late migrants).

No radio-marked geese were known to move from Wisconsin to southern Illinois during October or November, 1984-87. Thus, single sightings or radio-locations were considered adequate to establish the state a given bird used during fall. Most birds radio-marked October-November at Union County Refuge or Crab Orchard NWR stayed at the banding location until at least early December of the year they were marked (see Job II). Thus, banding site usually determined the specific fall location within southern Illinois for the year banding occurred.

Observations of an individual marked bird during October-November in 2 consecutive years constituted a sample for homing calculations. A few birds marked 1984-86 were relocated in >2 consecutive years; each fall-to-fall pair of observations constituted a sample for homing calculations.

Distribution of samples of marked birds representing segments of the MVP (e.g., early vs. late migrants) in time or among locations were compared using Chi-square or Z tests (Conover 1971). Results were considered significant with $P < 0.05$.

RESULTS

Radio Recoveries

Only 428 (80.1%) of the 534 MVP geese radio-marked during summer and fall in this study could be assumed to survive the winter with radios intact (Table 1). About 7% of radioed geese were shot by hunters, 4% were found dead (unknown causes), and 8% lost their radios prior to spring migration. Most (50%) of the geese "found dead" were banded in fall 1983 with radios mounted on their neck collars. About 70% of geese that lost their radios were banded in fall 1984 when backpack radio units had sharp edges on their mounting tabs.

The proportion of radioed geese shot by hunters varied from refuge to refuge and year to year in response primarily to when (relative to hunting season dates) they were marked, and secondarily to hunting season length (southern Illinois Quota Zone seasons varied from 25 days in 1984 to 50 days in 1987 and 1988).

Fall Homing

We obtained 127 sets of observations of individual radio-marked geese during consecutive falls (Table 2). A mean of 83% of geese staging in Wisconsin returned there the following fall. In contrast, only 37% of radioed birds located in southern Illinois during fall returned the next fall. Fall aerial counts conducted in Illinois and Wisconsin (Job IV) indicated an average 73% of geese were in Wisconsin 1985-86 (the 3 years when Wisconsin homing data were available). Assuming this 0.73 proportion represents the random chance probability a goose would fall-stage in Wisconsin, and 0.83 represents the proportion of MVP geese homing to Wisconsin 1985-87, there was no significant homing tendency among late migrants ($\underline{Z} = 0.9$, $\underline{P} > 0.20$). Similar calculations and assumptions applied to early migrants relocated 1984-87 (0.37 homing, 0.31 random chance) also suggests no significant homing tendencies ($\underline{Z} = 0.9$, $\underline{P} > 0.20$) among early migrants.

Of the 32 geese that were marked at Crab Orchard NWR and Union County Refuge and returned to southern Illinois the next fall, only 18 (56%) returned to the refuge where they were marked. Fall aerial counts (Job IV) indicated an average 61% of geese in southern Illinois were at Crab Orchard NWR and Union County Refuge. Assuming this 0.61 proportion represents a random chance probability of returning to Crab Orchard or Union County and that 0.56 represents actual fall-to-fall fidelity to these sites, there was no significant homing tendency to either refuge ($\underline{Z} = 0.5$, $\underline{P} > 0.60$). In fact, of

Table 1. Summary of banding and recovery information for adult female Canada geese radio-marked during fall 1983-88 and recovered through the following winter[a] (1984-89).

Year/Refuge	No. radioed	No. shot	No. found dead	No. lost radios	Assume active in spring[a]
1983					
Crab Orchard	25	1	5	0	19
Union County	35	6	5	0	24
Rend Lake	30	3	0	0	27
1984					
Crab Orchard	37	0	0	9	28
Union County	31	1	2	19	9
Rend Lake	18	0	0	1	17
Horicon[b]	15	0	0	2	13
1985					
Crab Orchard	40	1	2	3	34
Union County	21	2	0	1	18
Rend Lake	5	0	1	2	2
Horicon[b]	30	2	0	5	23
1986					
Crab Orchard	30	0	0	2	28
Union County	25	1	0	2	23
Rend Lake	3	0	0	2	1
Ontario[c]	39	5	0	-	26
1987					
Crab Orchard	28	5	1	0	22
Union County	19	0	0	0	19
Horicon[b]	30	5	0	0	25
1988					
Crab Orchard	30	0	1	4	26
Union County	23	3	2	0	18
Horseshoe Lake	20	0	1	0	19
Years Combined					
Crab Orchard	190	7	9	18	156
Union County	154	13	9	22	110
Rend Lake	56	3	1	5	47
Horseshoe Lake	20	0	1	0	19
Horicon	75	8	0	0	70
Ontario[c]	39	5	0	-	26
All locations	534	36	20	45	428
%		6.7	3.7	8.4	80.1

[a] See text for definition of when spring began and winter ended.

[b] Horicon National Wildlife Refuge in Wisconsin.

[c] See text for banding locations. Radio loss was not determined and number radio-marked birds assumed active in spring is based on telemetry locations during fall and winter in Wisconsin and/or Illinois.

Table 2. Homing among 127 radio-marked Canada geese located October-early December in 2 consecutive years between 1983 and 1987. Data indicate the percentage distributions of relocations of birds initially fall-staging in southeastern Wisconsin or at Union County or Crab Orchard refuges in southern Illinois.

		% relocations			
Initial location	No. relocated	Wisconsin	Crab Orchard	Union County	Other[a]
Wisconsin	41	83	5	5	7
Crab Orchard	54	65	22	6	7
Union County	32	59	19	19	3

[a] Other included 5 relocations at other southern Illinois area refuges and 2 relocations in the Upper Peninsula of Michigan.

the 86 radio-marked geese observed in southern Illinois one fall and observed anywhere the next, only 21% homed to specific refuges.

DISCUSSION AND CONCLUSIONS

No significant fall-fall homing tendency was found between early or late migrants or among geese that spent the fall at various southern Illinois refuges. Results suggest individual geese of the MVP fall stage primarily in response to overall goose distribution, and not on the basis of site fidelity. Lack of association between breeding distribution and previously identified segments of the MVP (Tacha et al. 1988), combined with low annual fidelity of individual geese to regional or local sites during fall hunting seasons (this study), casts serious doubts on the existence of manageable subpopulations (genotypic groups) or segments (traditional groups) within the MVP that uses Wisconsin and/or Illinois.

Subpopulations or segments of the MVP described by Kennedy and Arthur (1974), Craven (1978), and Craven and Rusch (1983) currently appear to be random aggregations that lack the necessary population integrity and annual site fidelity to be manageable as independent units. Although aggregations of the MVP fall-staging in different areas may have different survival rates, they are not manageable subpopulations. Harvest regulations, inventory, and other management activities can and should vary between states and/or areas within states as needed, but differential management should be primarily in response to spatial and temporal variation in distribution and abundance of birds. The lack of manageable subgroups emphasizes the need for integrated management of the MVP as a whole; priority should be given to managing cumulative impacts of harvest at all MVP locations.

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Job II. Distribution and movement activities (dispersal, egress, ingress) of Canada geese wintering in southern Illinois

Objective: To establish continuity of use of a given refuge by given units of Canada geese based upon different flight times and patterns in arriving in southern Illinois; to identify aspects of movements such as refuge interchange, dispersal, egress, ingress; and to relate such to motivating factors, i.e. food supply, weather, hunting, etc.

INTRODUCTION

The MVP grew from fall flights of about 300,000 to near 1 million from 1983 to 1988. This rapid growth held potential for major changes in winter distribution and movement patterns of the birds. Earlier studies (e.g. Anderson 1983, Paine and Tacha 1987) addressed smaller wintering populations and fall and/or winter movements of MVP geese associated with a specific refuge. This study documents fall and winter distribution and movements of MVP geese at all 4 major goose refuges in southern Illinois during 1983-84 to 1988-89, and relates these to environmental characteristics of the refuges to better understand factors influencing temporal and spacial variations in distributions of geese in southern Illinois.

METHODS

The 4 major goose refuges in southern Illinois are Crab Orchard National Wildlife Refuge (NWR), and state refuges at Rend Lake and Union County and Horseshoe Lake conservation areas (see Fig. 1, Job IV); these winter over 80% of the MVP each year (D. D. Thornburg, pers. comm.). Total area and area of permanent (roost) water were obtained from supervisors at each refuge, and did not significantly change 1984-88. At each refuge, area in cropland (grain and forage crops), grain (primarily soybeans, corn, milo, and sunflowers), and corn were inventoried via complete ground surveys each year. Cropland composition within 16km of each refuge was documented from crop reporting statistics at appropriate county Soil Conservation Service offices each fall. Resulting habitat availability and crop composition estimates by refuge and year are documented in Appendices II1-II8.

Availability (density in kg dry weight/ha) of waste and/or standing grain on and within 16km of each refuge was monitored immediately following (generally within 1 week) fall harvest each year 1984-88. Fields of each crop type (N=2-6 at each refuge) were surveyed using methods of Milner and Hughes (1968) and Frederick et al. (1984) to estimate grain density. Samples were oven dried for 24 hours and weighed to the nearest 0.1g (see also Pritchert 1988, Caithamer 1989, Gates 1989). Estimates of grain density were multiplied times areal availability of each grain crop at each refuge each year to estimate total biomass of high energy foods. Estimates of grain density by refuge and year are documented in Appendices II9-II12.

Area of each refuge and area within 16km of each refuge in grain and corn, and biomass of grain and corn, were selected as important environmental characteristics of each refuge because food energy availability is an important factor influencing condition and activities of wintering MVP geese (see Job VI). Total area, area of permanent water, and area in cropland at each refuge were variables selected to reflect more general environmental characteristics that might limit goose use through goose density.

Distributions of geese among the 4 refuges were monitored at weekly intervals October-January/February by aerial counts conducted by the Illinois Department of Conservation. Weekly counts of geese at each major refuge each year are documented in Appendices II13-II18.

Adult female geese were radio-marked at southern Illinois refuges, and in Wisconsin or Ontario, primarily during October-November (see Job I for banding information). Aerial surveys to locate radio-marked geese were made October-February 1983-89, averaging 1 every 4 days. An average of 95% of radioed geese were located each survey. All surveys included Union County CA, Crab Orchard NWR, Rend Lake, Campbell's Pond, Horseshoe Lake CA; Baldwin, Carlyle, Kinkaid, and Mermet lakes; and Ballard County Wildlife Management Area (WMA) in Kentucky. Hovey Lake in Indiana, and Reelfoot NWR in Tennessee were surveyed weekly. Additional surveys were conducted during fall and spring. During fall (October-December) and spring (February-April) these included central Illinois lakes, the Illinois River, the Rock River (Moline to Rockville, Illinois), southeastern Wisconsin (south of Green Bay and east of Lake Wisconsin, western Michigan (50 miles inland from Lake Michigan south of Manistee), Jasper-Palaski Wildlife Management areas in Indiana, and the Wabash River from Danville, Illinois to its confluence with the Ohio River (see Fig. 1 and methods, Job IV). During January each year, at least 1 survey was conducted that included the Mississippi River south of Reelfoot NWR, Big Lake NWR, Wappanoca NWR, Hatchie NWR and other major water bodies in northeastern Arkansas and southwestern Tennessee. Aircraft and telemetry equipment and their use are described in Job IV methods.

Additional sightings of radio-marked birds during winter were obtained from field personnel and as described in Job I methods. Methods for calculating winter homing follow those described for fall homing in Job I. However, primary wintering location was defined as the refuge where an individual radioed goose spent most of the winter period. At least 3 and usually 10-15 observations were required to establish primary winter residence.

Definitions and Analyses

In this job, fall was defined as from arrival of geese in October to the first major influx of late migrants in December; note different definitions were used when fall was split into 2 seasons (EFall and LFall, see below). Arrival of the first major influx of late migrants is defined as when weekly counts first increased in December (see Appendices II13-II18--dates are consistent with radio data in Job IV). Winter is defined as from the end of fall to first major northerly movement in spring. Using this criteria, winter ended February 13 in 1984, February 23 in 1985, January 19 in 1986, February 3 in 1987, February 4 in 1988, and February 23 in 1989 (see also Job IV).

Means and standard deviations (SD) of percentage distributions of Canada geese and habitat (environmental) characteristics among the 4 major refuges in southern Illinois were calculated for the period 1984-85 to 1988-89. Limiting data to major refuges was necessary to allow testing of associations between goose distributions and refuge characteristics, but disregards the 10-20% of the MVP that winter elsewhere. Thus, sampling and testing procedures limited conclusions and interpretations to the southern Illinois area. Associations between refuge habitat characteristics and goose use were tested by 1) generating a variable referred to as relative use and 2) testing relative use a) among refuges (1-way ANOVA) and/or b) within refuges using *t*-tests comparing relative use to 0. Relative use was calculated by subtracting the proportion (of all refuges) of fall, winter, or total goose use from the proportion (of all refuges) of total area, area of permanent roost water, cropland, grain, or corn at each refuge each year. For example, the association between fall goose use and corn availability at Crab Orchard NWR was tested by calculating the proportion of total fall goose at all 4 refuges that occurred at Crab Orchard in 1984, and subtracting the proportion of hectares of corn on all 4 refuges that was at Crab Orchard in 1984. The difference would be relative use of corn at Crab Orchard in 1984. Relative use of corn for each year 1984-88 was then compiled and the mean and SD among years calculated. This mean could then be tested against 0 (*t*-test of association between fall goose use and corn availability at Crab Orchard) or against means at other refuges (ANOVA and multiple range tests to determine if association varied among refuges).

Preliminary analyses of movements of radio-marked geese indicated there were 3 very different kinds. Short-term movements were subsequently defined as movements away from and back to a refuge within 8 days. Eight days was used because it generally encompassed 3 aerial surveys conducted 4 days apart. Long-term movements were defined as movements away from a refuge where the bird remained away for > 8 days. Mobile birds were those that moved every 4-12 days, resulting in a series of short-term movements that did not allow establishment of a winter residence.

Seasonal patterns of both long and short-term movements were summarized for major refuges for early fall (EFall-arrival to start of the goose hunting season), late fall (LFall-during goose hunting in the southern Illinois Quota Zone) and winter (after hunting until initiation of spring migration) each year 1983-84 to 1988-89. Destinations of long-term movements from each of the major refuges were also summarized.

RESULTS AND DISCUSSION

Goose Distributions

The proportional distribution of MVP Canada geese varied (ANOVAs) among the major refuges during fall ($P < 0.05$) but not winter ($P > 0.10$). Distribution was stable ($P > 0.5$) among years within seasons and refuges, but varied ($P < 0.01$) among seasons at some refuges (Table 1). An average of nearly 46% of geese spent the fall at Crab Orchard NWR, while only 7.7% spent the fall at Rend Lake. Average distributions of geese among refuges during winter were not significantly different, primarily because of high variances among years. Despite nearly tripling numbers of MVP geese during the study, distribution of geese among the refuges did not vary among years in fall, winter, or in total goose use (e.g., Crab Orchard consistently maintained about 46% of geese in fall, 25% in winter, and 30% overall). However, distributions of geese changed ($P < 0.01$) between fall and winter at Crab Orchard, Rend Lake, and Union County for 2 reasons: movement away from Crab Orchard in late fall (from 45% to 25% of birds), and influence of the distribution of late migrants after their arrival.

Distribution of early migrants changed dramatically from fall to winter as most early migrants at Crab Orchard and Rend Lake departed before or during arrival of late migrants (see long-term movements below). Late migrants were rather evenly distributed among the refuges upon arrival (see Job IV) and did not change distribution (X^2 test, $P > 0.30$) from arrival to winter (21% of late migrants wintered at Crab Orchard and Union County, 17% at Horseshoe Lake, 14% at Rend Lake, 12% at Ballard County KY, and 10% elsewhere). Combined distributions of early and late migrants are reflected in winter distributions discussed hereafter.

Analyses of associations between goose distributions and habitats among the major refuges yielded few significant ($P < 0.10$) results. Seasonal and total goose distributions were not associated ($P > 0.20$) with total area or areas of permanent water, cropland, grain, or corn (Table 1); or biomass of grain or corn. Associations were obscured by large variation among years in crop management at refuges (see SDs in Table 1). However, a few associations were evident within refuges and seasons. Proportional availability of total area, and cropland and corn hectares far exceeded ($\underline{P} < 0.01$) proportional goose use of Crab Orchard refuge in winter (Table 1). In contrast, winter goose use of Rend Lake refuge exceeded ($\underline{P} < 0.05$) proportional availability of cropland and corn. At Horseshoe Lake Refuge, proportional goose use exceeded ($\underline{P} < 0.05$) cropland availability in fall in all years; and availability of cropland, grain, and corn in both fall and winter of 1988-89.

Relatively low use of Crab Orchard NWR during winter could have been the result of relatively high use in fall. However, two sets of data suggest this is not the case. Fall use of Crab Orchard represented 46% or so of only 100,000-150,000 geese present in southern Illinois. This level of goose use was probably not enough higher than other refuges to reduce winter food availability more than observed at other refuges. Field sampling at Crab Orchard NWR in January 1986 and 1987 showed dramatic declines in food availability, but not more than experienced at other refuges (unpublished data, CWRL).

High relative use of Rend Lake refuge can be explained primarily on the basis of low availability of all habitats (except roost water) compared to other refuges. Pritchert (1988) suggested this overuse of a small refuge resulted in different activity patterns and lower physiological condition of geese at Rend Lake compared to other southern Illinois refuges.

High variability in percentage availability of croplands, grain, and corn at Horseshoe Lake limited ability to detect relatively high goose use of the refuge (Table 1). Horseshoe Lake averaged 32% of goose use in fall and winter with 25-27% of total cropland, grain, and corn. However, increases in fall and winter goose use to nearly 40% of total use of refuges in 1988 suggests the possibility of relative overuse of the refuge in the future.

Table 1. Mean (SD) percentage distribution of Canada geese and habitat characteristics among major refuges in southern Illinois, 1984-85 to 1988-89.

Variable	Crab Orchard	Rend Lake	Union County	Horseshoe Lake
Goose use				
Fall	45.6(2.6)	7.7(2.0)	14.5(2.0)	32.6(1.7)
Winter	25.3(5.1)	18.4(3.2)	24.3(3.3)	32.0(5.4)
Total	29.9(4.2)	15.9(2.5)	22.0(2.3)	32.2(4.6)
Total area[a]	53.0	12.7	16.7	17.5
Roost water[a]	30.3	33.1	14.0	22.7
Cropland	40.9(7.5)	8.8(1.6)	24.3(3.5)	26.0(4.9)
Grain	36.0(13.7)	13.5(1.2)	23.3(7.5)	27.2(8.0)
Corn	40.4(14.6)	10.0(3.4)	24.6(5.6)	25.1(6.5)

[a] Did not vary among years.

Movements

Long-term. - Long-term movements were common among early migrants (Table 2), but rare among late migrants (<2%). Late migrants appeared to move directly to wintering areas upon arrival in December-January, and few birds made long-term movements in winter (except early and late migrants from Rend Lake and Ballard County refuges).

Early migrants at Crab Orchard NWR were highly mobile, with 46-100% ($\bar{x}$=69%) making long-term movements away from the refuge (Table 2). Well over half of these departures occurred in late fall during the hunting season. Analyses of weekly departure rates generally indicated a steady rate of departures that was not associated ($P > 0.20$) with the advent of duck or goose hunting but that increased slightly ($P < 0.05$) with arrival of late migrants in December. Weekly departure rates did not increase ($P > 0.50$) during the 2 deer hunting seasons (3 days each) at Crab Orchard; if anything, deer hunting reduced long-term (and short-term) movement rates.

MVP geese using Rend Lake were also highly mobile (Table 2); on average 60% left the refuge during just the winter period. Most geese radioed at Rend Lake were marked during or after hunting, and birds were of unknown early and late-migrant status. Nevertheless, these geese departed at a high weekly rate during winter.

Radio-marked geese using Ballard County refuge in Kentucky were also highly mobile (Table 2) with an average 67% departing the refuge during winter. No birds were marked at Ballard County refuge, and sample sizes were small. Nevertheless, data indicate high winter mobility of geese using Ballard County.

Table 2. Seasonal pattern of movements (%) of radio-marked Canada geese away from major wintering refuges, 1983-84 to 1988-89. Geese that departed but returned within 8 days were not considered as changing their location[a].

		% moves by season			
Year/Refuge	No. radios monitored	EFall	LFall	Winter	Cumulative %
1983-84					
Crab Orchard	23	26	74	0	100
Union County	26	15	16	15	46
Rend Lake[b]	28	-	-	21	21
1984-85					
Crab Orchard	37	8	38	0	10
Union County	30	0	10	0	10
Rend Lake[c]	17	-	-	-	-
Horseshoe Lake[b]	4	-	0	0	0
Ballard County[b]	4	-	-	75	75
1985-86					
Crab Orchard	34	26	23	16	65
Union County	18	0	10	0	11
Rend Lake	3	33	33	34	100
Horseshoe Lake[b]	5	-	0	0	0
Ballard County[b]	7	-	-	71	71
1986-87					
Crab Orchard	29	21	31	3	55
Union County[b]	19	-	11	5	16
Rend Lake[b]	7	-	-	71	71
Horseshoe Lake[b]	6	-	0	0	0
Ballard County[b]	3	-	-	66	66
1987-88					
Crab Orchard	22	9	45	10	64
Union County	14	7	11	11	29
Rend Lake	4	7	11	11	29
Horseshoe Lake[b]	8	-	0	24	24
Ballard County[b]	3	-	-	66	66
1988-89					
Crab Orchard	26	15	61	8	84
Union County	18	5	28	0	33
Rend Lake[b]	7	-	0	57	57
Horseshoe Lake	25	8	4	0	12
Ballard County[b]	7	-	-	57	57

Table 2. Continued.

		% moves by season			
Year/Refuge	No. radios monitored	EFall	LFall	Winter	Cumulative %
Combined Years (total N and $\bar{x}$%)					
Crab Orchard	171	18	45	6	69
Union County	106	5	14	5	24
Rend Lake	47	–	–	60	60
Horseshoe Lake	48[d]	8	1	5	7
Ballard County	24	–	–	67	67

[a] Data are summarized within rows; only birds marked and monitored for a complete season were included, although time marked during EFall varied.

[b] Dashes indicate radios were not available during that season.

[c] Radios were not placed on geese until February.

[d] Only 25 radios from 1988-89 were available during EFall and LFall; this explains why cumulative % is not sum of seasons.

Radio-marked geese using Union County and Horseshoe Lake refuges departed at significantly ($P < 0.01$) lower rates ($\bar{x}$=24% and 7%, respectively) than observed at Crab Orchard, Rend Lake, and Ballard County (Table 2). Most long-term movements from Union County occurred during hunting in late fall. The literal interpretation of these data is that (on average) 93% of geese that arrive at Horseshoe Lake and 76% of geese arriving at Union County do not leave for any extended period (<8 days) until spring migration.

The distribution of destinations of geese departing major refuges did not vary ($P > 0.20$) among years or seasons. Data were pooled across years and seasons for further analyses (Table 3).

Geese making long-term movements away from Crab Orchard NWR appeared scattered (Table 3). About 36% moved southwest to Union County and Horseshoe Lake, 17% south to Ballard County, 23% north to Campbell Pond and Rend Lake, and 13% east to Will Scarlett mine near Harrisburg and Hovey Lake, Indiana.

Geese departing Union County refuge showed a strong affinity for Crab Orchard (40%) and Horseshoe Lake (30%) refuges (Table 3). Although sample sizes were small, geese from Rend Lake showed a strong affinity for Crab Orchard (40%) and Union County and Horseshoe Lake Refuges (45% total). Birds from Ballard County exhibited a strong affinity for Horseshoe Lake (56%) and some association with Reelfoot NWR in Tennessee (19%).

Two major patterns emerge from analyses of destinations of long-term movements. First, geese from Crab Orchard NWR seemed to be dispersing rather than moving in a specific direction. Second, there was a distinct tendency for geese in general to move south and west, especially to Horseshoe Lake and Union County.

Table 3. Percentage distribution of destinations of radio-marked Canada geese deporting major refuges in southern Illinois during fall and winter, 1983-84 to 1988-89. Data are summarized with years and seasons combined, and exclude movements where the goose returned within 8 days and spring migratory movements.

Initial location	No. departing	Crab Orchard	Union County	Rend Lake	Horseshoe Lake	Ballard County	Campbell's Pond	Hovey Lake, TN	Reelfoot NWR, IN	Will Scarlett Mine	Other[a]
Crab Orchard	108		18	16	18	17	7	10	3	3	7
Union County	30	40		13	30	10	3	0	0	0	4
Rend Lake	20	40	20		25	10	0	5	0	0	0
Horseshoe Lake	5	20	20	0		40	0	0	20	0	0
Ballard County	16	6	13	0	56		0	6	19	0	0

[a] Other includes various lakes, rivers, and ponds in southern Illinois, as well as movements of 2 birds from Crab Orchard to Arkansas in January, 1984.

Short-term. - Of the 58 late migrants monitored through winter, 41% made at least 1 short-term winter-refuge movement (from 1 refuge to another and back in <8 days). In general, these movements were to the nearest refuge.

Over 78% of radio-marked geese at Rend Lake and Crab Orchard made at least 1 long or short-term movement; while 60-69% of birds made long-term movements, only 9-18% made short-term movements. In contrast, about 47% of radioed birds at Union County and Horseshoe Lake made 1 or more inter-refuge movements, with 7-24% making long-term but 23-40% making short-term moves.

Although 3-9 times more birds made long-term moves at Crab Orchard and Rend Lake, 2-3 times more birds made short-term moves at Union County and Horseshoe Lake. Most of the short-term moves at Union County and Horseshoe Lake occurred during winter after arrival of late migrants. Both early and late migrants made their short-term movements to nearby areas.

Patterns of short-term movements were difficult to identify, but several inter-refuge relationships were apparent. The most obvious association was among Rend Lake, Campbell's Pond, and Crab Orchard NWR; short-term movements between these areas occurred throughout fall and winter. Other strong associations were between Union County and Horseshoe Lake in fall, and Ballard County and Horseshoe Lake in winter. A growing association between the Cache River bottoms near Interstate Highway 57 and Horseshoe Lake during winter became apparent in January of 1988 and 1989. Over 90% of locations of radioed geese on mine lands were from geese making short-term movements from Rend Lake, Campbell's Pond, or Crab Orchard. Mines most used were the Will Scarlett mine near Harrisburg and the Captain mine near Sparta.

Each year a small number of radio-marked geese we re so mobile that no winter residence could be established. An average of 7% of all radioed birds were this "mobile", and this percentage did not vary ($P > 0.50$) by year, early or late migrant status, or banding location. Weak evidence (Unpubl. data, CWRL) exists that these "mobile" birds were primarily unpaired adults (all geese radioed in this study were adult females and most were paired or parents).

Winter Homing

About 63% of MVP geese wintering at Union County refuge returned there the following winter. About 64% winter homing was observed at Horseshoe Lake, and about 40% at other refuges. Using January data from Illinois aerial counts (see Job IV), about 20% of geese wintering in the southern Illinois area 1985-88 were at Crab Orchard, 20% at Union County, 28% at Horseshoe Lake, and 12% at Rend Lake. If these percentages are assumed to reflect the random chance probability of where a returning goose would winter, then these data demonstrated significant (*Z*-tests, $P<0.001$) homing tendencies at all refuges. Geese wintering at Union County were nearly 3 times as likely to return as expected from random chance, while geese at Horseshoe Lake, Rend Lake, and Crab Orchard were twice as likely to return.

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Fall and winter distributions of MVP geese in the southern Illinois area appear to have generally remained stable 1983-89 despite a nearly 3-fold increase in goose use. However, goose use of Horseshoe Lake Refuge in winter increased dramatically in 1988-89. Fall distribution will probably remain similar for some time to come, but winter distribution may change with increased goose use of Horseshoe Lake refuge.

Distributions of geese among southern Illinois refuges was generally poorly associated with quantity and quality of habitat as measured in this study. This suggests some other factor(s) is influencing goose distribution, especially during winter. However, comparisons of goose and habitat distributions supported the conclusions of Pritchert (1988) that Rend Lake refuge has inadequate cropland to properly support even current goose use. Relative use comparisons also indicate Horseshoe Lake may have been over-used by geese, relative to available habitat, in recent years.

Most geese present at Crab Orchard, Rend Lake, and Ballard County refuges leave before the end of winter. Crab Orchard and Rend Lake refuges appear to function as terminal staging areas for fall-migrating geese, especially early migrants. Ballard County appears to function primarily as a way station for geese from Crab Orchard and Rend Lake moving south and west, and for short-term movements of geese from Horseshoe Lake. Distribution and movements data both lead to the suggestion that Crab Orchard, Rend Lake, and (later on in January) Ballard County refuges be managed primarily (but not exclusively) for fall use and recreation. Winter goose use of these areas may not increase, regardless of habitat management efforts.

Evidence indicates a strong tendency for geese to move south and west to winter at Horseshoe Lake and Union County refuges. Low rates of long-term movement away from these refuges emphasizes their importance as primary wintering areas. High rates of short-term movements in winter may be consistent with overuse of refuge food and other resources in winter (see also Job VI).

Distribution and movement information are both consistent with the hypothesis that the primary factor influencing winter distribution of MVP geese in southern Illinois is a strong traditional use of the Mississippi River Valley in general and Horseshoe Lake in particular (see also Hanson and Smith 1950). Relative use, movements, and Job VI data all indicate a serious problem of limited food resources in winter is evolving at Horseshoe Lake and (to a lesser extent) Union County refuges. Goose use now (1989) exceeds available food resources, and the problem will probably worsen until food resource availability is dramatically improved via increasing cropland acreage (refuge size) and/or more efficient (for maximizing food energy production) crop management. Maximum effort should be expended to improve the quantity and quality of habitat at Horseshoe Lake and Union County refuges and/or to reduce goose use of these areas via population reduction (see also Job VI).

Distribution and movements also identified several locations that are important to geese but that are not currently protected adequately. The Campbell's Pond area was by far the most important of these. Current IDOC efforts to protect and enhance this area should continue. Other such areas of relative import are the Cache River bottoms near I57 and the Will Scarlett mine near Harrisburg.

Tripling of goose use of southern Illinois refuges 1983-89 leads to the recommendation that at least one additional refuge, or large-scale expansion of existing refuges, is needed. First and foremost is the need for additional refuge land area to support food resources for geese in late fall and winter. Based on distribution and movements in the past, a new or greatly expanded refuge is needed in the Mississippi River Valley near Horseshoe Lake. Priority should be given to land acquisition and improved land management on existing lands in the area. Recent increases in winter use of the Cache River bottoms suggest a refuge including this area would be beneficial. Current efforts to establish a refuge complex in this area are encouraged; these efforts should consider providing habitat, including croplands and open roosting water, for wintering Canada geese.

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Appendix I11. Habitat availability and crop composition on and within 16 km of Crab Orchard National Wildlife Refuge (inviolate portion) during fall-winter, 1984-1989.

	1984-85		1985-86		1986-87		1987-88		1988-89	
Variable	ha	%	ha	%	ha	%	ha	%	ha	%
Corn	5,815	4.5	8,893	6.9	9,749	7.5	13,448	10.4	14,048	11.4
Soybeans	10,435	8.0	9,465	7.3	8,615	6.6	12,741	9.8	10,625	8.6
Grain sorghum	8,243	6.4	8,527	6.6	3,792	2.9	2,038	1.6	1,235	1.0
Winter wheat	3,155	2.4	1,213	0.9	2,427	1.9	2,984	2.3	2,347	1.9
Forage	19,441	15.0	17,543	13.5	21,543	16.6	16,125	12.4	18,655	15.1
Other crops	243	0.2	2,791	2.2	2,306	1.8	649	0.5	124	<0.1
Cropland total	47,332	36.5	48,432	37.3	48,432	37.3	47,985	37.0	47,070	36.3
Permanent water	4,448	3.4	4,448	3.4	4,448	3.4	4,448	3.4	4,448	3.4
Area not useable	77,982	60.0	76,882	59.2	76,882	59.2	77,329	59.6	78,224	60.3
Total	129,762	99.9	129,762	99.9	129,762	99.9	129,762	100.0	129,762	100.0

Appendix II2. Habitat availability and crop composition on the inviolate refuge portion of Crab Orchard National Wildlife Refuge during fall-winter, 1984-89.

	1984-85		1985-86		1986-87		1987-88		1988-89	
Variable	ha	%	ha	%	ha	%	ha	%	ha	%
Corn	112	1.3	520	6.2	648	7.7	707	8.4	712	8.5
Soybeans	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Grain sorghum	113	1.3	154	1.8	152	1.8	96	1.1	42	0.5
Winter wheat	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Other forage	876	10.4	1,526	18.1	1,400	16.6	714	8.5	1,444	17.2
Other crops	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Cropland total	1,101	13.0	2,200	26.1	2,200	26.1	1,517	18.0	2,198	26.1
Permanent water	1,295	15.4	1,295	15.4	1,295	15.4	1,295	15.4	1,295	15.4
Area not useable	6,022	71.5	4,923	58.5	4,923	58.5	5,606	66.6	4,925	58.5
Total	8,418	99.9	8,418	100.0	8,418	100.0	8,418	100.0	8,418	100.0

Appendix II3. Habitat availability and crop composition on and within 16 km of Rend Lake Wildlife Management Area during fall-winter, 1984-1989.

	1984-85		1985-86		1986-87		1987-88		1988-89	
Variable	ha	%	ha	%	ha	%	ha	%	ha	%
Corn	17,747	15.5	15,792	13.8	19,046	16.6	15,251	13.3	15,920	13.9
Soybeans	20,517	17.9	20,193	17.7	20,313	17.8	23,220	20.3	19,793	17.2
Grain sorghum	8,123	7.1	10,854	9.5	5,519	4.8	3,759	3.3	2,228	1.9
Winter wheat	5,109	4.5	3,559	3.1	5,006	44.4	5,477	2.3	7,021	6.1
Forage	10,109	8.8	10,155	8.9	11,856	10.4	13,139	12.4	16,909	14.7
Other crops	112	0.1	1,235	1.1	1,146	1.0	898	0.8	0	0.0
Cropland total	61,717	54.0	61,788	54.0	62,886	55.0	61,744	54.0	61,871	53.9
Permanent water	9,389	8.2	9,389	8.2	9,389	8.2	9,389	8.2	9,389	8.2
Area not useable	43,213	37.8	43,190	37.8	42,144	36.8	43,189	37.8	43,613	38.0
Total	114,319	100.0	114,367	100.0	114,419	100.0	114,322	100.0	114,873	100.1

Appendix II4. Habitat availability and crop composition on the inviolate refuge portion of Rend Lake Management Area during fall-winter, 1984-89.

	1984-85		1985-86		1986-87		1987-88		1988-89	
Variable	ha	%	ha	%	ha	%	ha	%	ha	%
Corn	116	5.7	70	3.4	167	7.9	115	5.2	134	6.2
Soybeans	79	3.9	92	4.4	61	2.9	87*	3.9	75	3.5
Grain sorghum	38	1.9	74	3.6	27	1.3	53	2.4	17	0.8
Winter wheat	56	2.8	78	3.8	86	4.0	144*	6.5	141	6.5
Other forage	2	0.1	48	2.3	71	3.3	106	4.8	78	3.6
Other crops	0	0.0	0	0.0	2	0.1	14	0.6	0	0.0
Cropland total	291	14.4	362	17.5	414	19.5	519*	23.3	445	20.6
Permanent water	1,416	70.0	1,416	68.4	1,416	66.7	1,416	63.6	1,416	65.8
Area not useable	315	15.6	292	14.1	292	13.8	292	13.1	292	13.6
Total	2,022	100.0	2,070	100.0	2,122	100.0	2,227	100.0	2,153	100.0

*In same fields (soybean/wheat double crop).

** Larger than actual acreage values due to double cropping (soybean/wheat) of 87ha in 1987-88, and 75 ha in 1988-89.

Appendix II5. Habitat availability and crop composition on and within 16 km of Union County Conservation Area (including refuge and public shooting areas) during fall-winter, 1984-1989.

	1984-85		1985-86		1986-87		1987-88		1988-89	
Variable	ha	%	ha	%	ha	%	ha	%	ha	%
Corn	3,596	4.1	6,351	7.2	7,919	9.0	7,616	13.3	4,594	5.5
Soybeans	11,277	12.8	10,250	11.6	10,512	11.9	10,231	20.3	9,742	11.6
Grain sorghum	2,300	2.6	4,305	4.9	1,795	2.0	967	3.3	136	0.2
Winter wheat	8,564	9.7	6,628	7.5	6,256	7.1	6,871	2.3	6,945	8.3
Forage	604	0.7	513	0.6	598	0.7	2,692	12.4	3,568	4.2
Other crops	2,749	3.1	1,129	1.3	1,855	2.1	588	0.8	0	0.0
Cropland total	29,090	33.0	29,176	33.1	28,935	32.9	28,965	54.0	24,985	29.6
Permanent water	3,759	4.3	3,759	4.3	3,759	4.3	3,759	8.2	3,759	4.5
Area not useable	55,288	62.7	55,265	62.7	55,316	62.8	55,290	37.8	55,290	65.8
Total	88,137	100.0	88,200	100.1	88,010	100.0	88,014	100.0	84,034	99.1

Appendix II6. Habitat availability and crop composition on Union County Conservation Area refuge and public shooting areas during fall-winter, 1984-89.

	1984-85		1985-86		1986-87		1987-88		1988-89	
Variable	ha	%	ha	%	ha	%	ha	%	ha	%
Corn	263	9.8	283	10.3	313	12.3	272	10.2	346	13.0
Soybeans	168	6.3	166	6.1	0	0.0	0	0.0	0	0.0
Grain sorghum	164	6.1	32	1.2	0	0.0	41	0.0	33	1.2
Winter wheat	445	16.6	474	17.3	445	17.4	536	20.2	671	25.3
Other forage	91	3.4	171	6.2	171	6.7	85	3.2	2	0.1
Other crops	14	0.5	103	3.8	60	2.4	0	0.0	0	0.0
Cropland total	1,145	42.8	1,229	44.9	989	38.8	934	33.6	1,052	39.6
Permanent water	597	22.3	597	21.8	597	23.4	597	22.5	597	22.5
Area not useable	936	35.0	913	33.3	964	37.8	1,125	43.9	1,007	37.9
Total	2,678	100.1	2,739	100.0	2,550	100.0	2,656	100.0	2,656	100.0

Appendix II7. Habitat availability and crop composition on and within 16 km of Horseshoe Lake Conservation Area during fall-winter, 1984-1989.

	1984-85		1985-86		1986-87		1987-88		1988-89	
Variable	ha	%	ha	%	ha	%	ha	%	ha	%
Corn	5,589	5.1	7,385	6.8	8,805	8.1	4,877	4.5	8,330	7.6
Soybeans	16,491	15.2	15,495	14.2	17,192	15.8	18,150	16.7	17,024	15.6
Grain sorghum	9,218	8.4	9,666	8.9	3,361	3.1	2,671	2.4	703	0.6
Winter wheat	9,375	8.6	9,294	8.5	10,355	9.5	11,242	10.3	12,291	11.3
Forage	1,785	1.6	1,126	1.0	2,081	1.9	7,102	6.5	5,716	5.2
Other crops	1,916	1.8	1,380	1.3	2,547	2.3	86	0.1	0	0.0
Cropland total	44,374	40.7	44,346	40.7	44,341	40.7	44,128	40.5	44,064	40.4
Permanent water	5,428	5.0	5,428	5.0	5,428	5.0	5,428	5.0	5,428	5.0
Area not useable	59,264	54.3	59,249	54.3	59,147	54.3	59,340	54.5	59,404	54.6
Total	109,066	100.0	109,023	100.0	108,916	100.0	108,896	100.0	108,896	100.0

Appendix II8. Habitat availability and crop composition on Horseshoe Lake Conservation Area (refuge and public shooting areas combined) during fall-winter, 1984-89.

	1984-85		1985-86		1986-87		1987-88		1988-89	
Variable	ha	%	ha	%	ha	%	ha	%	ha	%
Corn	283	10.0	275	9.8	315	11.7	310	11.2	313	11.3
Soybeans	42	1.5	107	3.8	0	0.0	0	0.0	0	0.0
Grain sorghum	304	10.7	221	7.9	283	10.5	0	0.0	21	0.8
Winter wheat	567	20.0	486	17.4	486	18.1	567	20.4	502	18.1
Other forage	87	3.1	171	6.1	171	6.4	122	4.4	100	3.6
Other crops	6	0.2	0	0.0	0	0.0	0	0.0	0	0.0
Cropland total	1,289	45.4	1,260	45.1	1,255	46.7	999	36.0	939	33.8
Permanent water	971	34.2	971	34.7	971	36.1	971	35.0	971	35.0
Area not useable	579	20.4	564	20.2	462	17.2	804	29.0	867	31.2
Total	2,839	100.0	2,795	100.0	2,688	100.0	2,774	100.0	2,774	100.0

Appendix II9. Density of waste grain and standing grain in fields (kg/ha) on refuge and private lands surrounding 4 southern Illinois goose refuges during 1984 and 1985.

Year Crop type	Variable	Crab Orchard	Rend Lake	Union County	Horseshoe Lake	All areas
1984						
Harvested corn	$\bar{x}$	236	162	218	148	188
	SE	37	54	113	84	36
	N	5	6	5	6	22
Harvested soybeans	$\bar{x}$	-	-	438	-	438
	SE	-	-	3	-	3
	N	-	-	2	-	2
Harvested milo	$\bar{x}$	186	508	163	86	197
	SE	166	-	68	81	69
	N	2	1	2	2	7
1985						
Harvested corn	$\bar{x}$	295	158	192	287	222
	SE	80	52	72	24	34
	N	7	8	9	4	28
Harvested soybeans	$\bar{x}$	-	233	163	-	198
	SE	-	100	39	-	52
	N	-	8	8	-	16
Harvested milo	$\bar{x}$	119	147	-	-	133
	SE	63	39	-	-	34
	N	3	3	-	-	6
Unharvested milo	$\bar{x}$	557	-	943	-	711
	SE	222	-	759	-	285
	N	3	-	2	-	5

Appendix III0. Density of waste grain and standing grain in fields (kg/ha) on refuge and private lands surrounding 4 southern Illinois goose refuges during 1986.

Crop type		Crab Orchard	Rend Lake	Union County	Horseshoe Lake	All areas
Harvested	$\bar{x}$	327	137	230	288	229[a]
corn	SE	170	30	71	85	
	N	7	10	11	4	32
Unharvested	$\bar{x}$	-	-	4156	-	4156
corn (mowed)	SE	-	-	1306	-	1306
	N	-	-	4	-	4
Harvested	$\bar{x}$	119	90	-	109[a]	
soybeans	SE	-	23	18	-	-
	N	-	10	5	-	15
Harvested	$\bar{x}$	101	-	-	129	112
milo	SE	12	-	-	55	20
	N	3	-	-	2	5
Unharvested	$\bar{x}$	5877	-	-	-	5877
milo	SE	730	-	-	-	730
	N	3	-	-	-	3
Winter[b]	$\bar{x}$	-	235	1913	-	1074
wheat	SE	-	233	358	-	-
	N	-	2	2	-	4
Other green[b]	$\bar{x}$	-	2112	1748	-	1869
forage	SE	-	95	-	-	-
	N	-	2	4	-	6

[a] Standard errors not calculated. Means are weighted by sample size across locations.

[b] Values are peak densities of green forages observed in November.

Appendix III1. Density of waste grain, standing grain and forage in refuge and private fields surrounding 4 southern Illinois goose refuges during 1987.

Crop type	Variable	Crab Orchard	Rend Lake	Union County	Horseshoe Lake	All areas
Harvested corn	$\bar{x}$	203	91	263	303	219
	SE	57	33	50	82	32
	N	8	8	9	9	34
Harvested soybeans	$\bar{x}$	82	-	138	128	126
	SE	-	-	-	-	-
	N	1	-	3	3	7
Winter[b] wheat	$\bar{x}$	-	-	136	27	89
	SE	-	-	35	12	29
	N	-	-	4	3	7
Other green[b] forage	$\bar{x}$	-	-	265	22	144
	SE	-	-	-	-	122
	N	-	-	1	1	2

[a] Standard errors not calculated.

[b] Green forage and winter wheat densities were determined from data collected in November.

Appendix II12. Density of waste grain and forage on and near refuge and private lands surrounding 4 southern Illinois goose refuges during 1988.

Crop type	Variable	Crab Orchard	Rend Lake	Union County	Horseshoe Lake	All areas
Harvested corn	$\bar{x}$	353	151	342	450	348
	SE	77	59	82	68	41
	N	8	4	9	8	29
Harvested soybeans	$\bar{x}$	-	-	130	128	159
	SE	-	-	a	a	a
	N	-	-	3	3	6
Winter[b] wheat	$\bar{x}$	-	-	124	72	109
	SE	-	-	8	40	14
	N	-	-	5	2	7
Other green[b] forage	$\bar{x}$	-	-	-	156	156
	SE	-	-	-	-	-
	N	-	-	-	1	1

[a] Standard errors not calculated.

[b] Green forage and winter wheat densities were determined from data collected in November.

Appendix II13. Estimates from aerial surveys of Canada goose populations on MVP wintering areas during fall and winter, 1983-84.

	Ballard Co.	Horseshoe Lake	Union Co.	Crab Orchard*	Rend Lake	Total
10-31-83	4,000	40,000	18,000	74,500	7,000	143,500
11-07-83	4,000	37,000	28,000	69,000	8,000	146,000
11-14-83	6,000	51,000	24,000	63,500	3,500	148,000
11-21-83	7,000	26,000	23,000	54,500	5,000	115,500
12-20-83	40,000	110,000	57,000	48,000	38,000	293,000
01-09-84	18,000	38,000	43,000	10,500	34,000	143,500
01-31-84	21,000	35,000	42,000	44,000	35,000	177,000
02-07-84	35,000	25,000	35,000	40,000	44,000	179,000
01-14-84	3,000	4,000	10,000	8,000	12,000	37,000

*Includes Campbell Pond.

Appendix II14. Estimates from aerial surveys of Canada goose populations on MVP wintering areas during fall and winter, 1984-85.

	Ballard Co.	Horseshoe Lake	Union Co.	Crab Orchard*	Rend Lake	Total
10-15-84	3,000	15,000	9,000	20,150	2,000	49,150
10-22-84	3,000	27,500	17,500	39,400	3,500	89,900
10-29-84	5,000	27,000	15,000	40,000	6,000	93,000
11-05-84	4,000	32,000	19,000	49,500	6,500	111,000
11-13-84	4,000	27,000	14,000	50,000	6,000	101,000
11-19-84	5,000	29,000	16,000	38,500	7,000	95,500
11-29-84	8,000	28,000	16,000	29,000	13,000	94,000
12-03-84	5,000	31,000	17,000	28,500	8,500	90,000
12-10-84	8,000	40,000	20,000	52,000	13,000	133,000
01-07-85	35,000	75,000	58,000	84,000	64,000	316,000
01-14-85	35,000	95,000	63,000	98,000	72,000	363,000
01-21-85	50,000	125,000	60,000	87,000	62,000	384,000
01-28-85	55,000	125,000	60,000	68,000	48,000	356,000
02-04-85	49,000	95,000	54,000	51,500	42,000	291,500

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*Includes Campbell Pond.

Appendix III5. Estimates from aerial surveys of Canada goose populations on MVP wintering areas during fall and winter, 1985-86.

	Ballard Co.	Horseshoe Lake	Union Co.	Crab Orchard*	Rend Lake	Total
10-15-85	1,500	20,000	8,000	22,200	2,500	59,200
10-28-85	4,500	21,000	9,000	34,000	6,500	75,000
11-04-85	6,500	26,000	8,000	38,500	6,500	85,500
11-20-85	5,500	18,000	8,000	30,500	8,000	70,000
12-02-85	8,500	28,000	18,000	94,000	18,000	166,500
12-09-85	40,000	76,000	74,000	95,000	70,000	355,000
12-16-85	40,000	90,000	96,000	52,000	60,000	338,000
01-07-86	13,000	105,000	95,000	27,500	65,000	305,500
01-13-86	10,000	85,000	95,000	43,000	65,000	298,000
01-21-86	5,000	35,000	30,000	32,000	36,000	138,000
01-27-86	11,000	28,000	39,000	23,000	27,000	128,000

*Includes Campbell Pond.

Appendix II16. Estimates from aerial surveys of Canada goose populations on MVP wintering areas during fall and winter, 1986-87.

	Ballard Co.	Horseshoe Lake	Union Co.	Crab Orchard*	Rend Lake	Total
10-14-86	3,000	26,000	15,000	42,700	2,000	88,700
10-20-86	4,000	35,000	14,000	48,000	2,500	103,500
10-27-86	3,500	28,000	3,000	43,500	2,500	80,500
11-03-86	6,000	31,000	16,000	43,500	4,500	101,000
11-10-86	4.000	30,000	6,000	45,300	6,000	91,300
11-24-86	5,000	22,000	15,000	41,500	12,000	95,500
12-10-86	13,000	48,000	38,000	71,500	30,000	200,500
12-15-86	37,000	75,000	61,000	94,000	60,000	327,000
12-22-86	27,000	80,000	74,000	85,000	65,000	331,000
01-05-87	27,000	95,000	63,000	57,000	60,000	302,000
01-12-87	15,000	55,000	46,000	49,000	38,000	203,000
01-26-87	28,000	68,000	64,000	47,000	55,000	262.000

*Includes Campbell Pond.

Appendix III7. Estimates from aerial surveys of Canada goose populations on MVP wintering areas during fall and winter, 1987-88.

	Ballard Co.	Horseshoe Lake	Union Co.	Crab Orchard*	Rend Lake	Total
10-13-87	3,000	20,000	12,000	47,500	6,000	88,500
10-19-87	4,000	32,000	12,000	53,300	6,000	107,300
10-27-87	3,500	37,000	16,000	49,000	5,000	110,500
11-02-87	4,500	32,000	14,000	54,050	9,000	113,550
11-09-87	3,500	45,000	18,000	52,300	9,000	127,800
11-18-87	2,700	40,000	14,000	54,100	10,000	120,800
11-23-87	8,000	44,000	15,000	58,500	10,000	135,500
12-09-87	11,000	42,300	18,000	64,800	12,000	148,100
12-16-87	13,000	45,000	34,000	46,000	18,000	156,000
12-21-87	22,000	163,850	105,000	163,000	68,000	521,850
12-29-87	28,000	112,000	132,000	177,000	50,000	499,000
01-04-88	36,000	160,000	112,000	190,000	50,000	571,500
01-11-88	45,300	170,000	120,000	172,000	74,000	611,300
01-25-88	22,000	55,000	90,000	54,000	110,000	339,500

*Includes Campbell Pond.

Appendix II18. Estimates from aerial surveys of Canada goose populations on MVP wintering areas during fall and winter, 1988-89.

	Ballard Co.	Horseshoe Lake	Union Co.	Crab Orchard*	Rend Lake	Total
10-18-88	1,500	34,000	11,000	48,500	4,500	99,500
10-24-88	3,500	42,000	10,000	48,500	7,000	111,000
10-31-88	3,000	45,000	14,000	54,000	7,500	123,500
11-07-88	6,000	45,000	17,000	56,500	9,500	134,000
11-14-88	6,000	48,000	14,000	52,500	14,000	134,500
11-21-88	6,000	57,000	14,000	72,000	7,500	156,600
11-28-88	6,000	38,000	17,000	70,500	7,000	138,500
12-05-88	20,000	91,000	35,000	104,000	17,000	267,000
12-12-88	21,000	110,000	76,000	85,000	40,000	332,000
12-19-88	26,000	135,000	86,000	83,000	72,000	402,000
01-04-89	40,000	260,000	135,000	129,000	90,000	656,500
01-10-89	35,000	300,000	120,000	100,000	75,000	634,000
01-17-89	54,100	240,000	230,000	86,000	70,000	684,100
01-23-89	69,000	220,000	150,000	78,000	135,000	692,000

*Includes Campbell Pond.

Job III. Contribution of early and late migrants to southern Illinois hunting

Objective: Investigate the hunter harvest as it relates to relative impact on early and late migrants.

This Job presumes the existence of manageable segments of the MVP associated with early and late migrants. Jobs I and IV and Tacha et al. (1988, J. Wildl. Manage. 52:689-693) provided results and associated conclusions that early and late migrants are not subpopulations (genotypic groups) with distinct breeding distributions, or segments (traditional groups) with adequate site fidelity to be managed separately. The high annual rate of interchange between early and late migrants makes impact of harvest of each group much less important than impact on the MVP as a whole (see Job I).

Job IV. Patterns of movement of Canada geese to and from breeding grounds in Canada

Objective: Establish a more precise analysis of migration of the southern Illinois wintering population to and from the breeding grounds with special emphasis on the impact of intermediate "stopping sites" as these affect migratory activity, behavior, and physiological condition.

INTRODUCTION

The specific objectives of this Job are to describe routes and chronology of fall and spring migration of Canada geese of the MVP, and to relate these migration patterns to harvest and habitat management practices. Knowledge of migration routes and chronology allows identification of important migration staging areas. Spatial and temporal distributions of the MVP in fall affect success of harvest regulations (Kennedy and Arthur 1974, Craven et al. 1986), while conservation and management of key spring staging areas can influence resource availability, physiological condition, and subsequent reproduction (Raveling and Lumsden 1977, Gates 1989).

The annual range of the MVP has been described by Hanson and Smith (1950), Vaught and Arthur (1965), and Reeves et al. (1968); Craven and Rusch (1983:fig. 1) summarized the resultant range maps and important migration staging and wintering areas. Craven and Rusch (1983) also documented the general fall migration chronology of the MVP in Wisconsin, and Craven (1978) and Craven et al. (1986) described fall-to-fall homing to refuges in southeastern Wisconsin. These studies were based primarily on leg and neck band recovery information. Radio-telemetry was used in this study to more frequently monitor locations of individual geese representative of major segments of the MVP, and to more precisely identify relationships of these segments to migration chronology and specific fall and spring use areas.

W. D. Klimstra, D. D. Thornburg, and A. Woolf provided assistance throughout the study. Personnel from the Moosonee District of the Ontario Ministry of Natural Resources, Horicon National Wildlife Refuge (NWR), Crab Orchard NWR, and Union County Refuge assisted with trapping and banding efforts. Personnel of the Illinois Department of Conservation, Wisconsin Department of Natural Resources, Horicon NWR, and the Northeastern, Northern, Northwestern, and North Central regions of the Ontario Ministry of Natural Resources contributed counts of migrating Canada geese. D. H. Rusch and other staff of the Wisconsin Cooperative Wildlife Research Unit shared information on sightings of radio-marked geese. K. F. Abraham, D. F. Caithamer, R. J. Gates, C. R. Paine, and R. D. Pritchert provided valuable field assistance.

METHODS

Definitions of seasons and sampling (marking and recoveries) were reported in Job I. Data from geese marked 1983-87 were used in this job. Radio-marked geese were generally monitored in wintering areas twice/week via aerial surveys during October-February 1983-88. Those shot by hunters, found dead, or that lost radios during fall and winter were excluded from subsequent spring migration surveys.

Weekly aerial surveys were also conducted to monitor radio-marked geese during fall (October-December 1984-86) and spring (February-April 1984-86) migration. Each survey generally encompassed the area identified in Fig. 1 in central and northern Illinois, southern Wisconsin, western Michigan, and western Indiana. However, surveys of the Mississippi and Wisconsin River areas were generally conducted every other week, alternating with surveys of western Michigan and Indiana. Additional aerial surveys were flown within 80 km of the coasts of the Hudson and James bays in Ontario during September 1986 following search methods of Tacha et al. (1988).

A Cessna 310 was used to fly migration surveys; mean ground speed of 175 km/hour and altitude of 1,350 m above ground level were usually maintained. Air-to-ground radio detection range was about 40 km, but locations of radio-marked birds could be plotted within about 3 km using direction and radio signal strength. Tacha et al. (1988:691) described directional receiving equipment and scanning receivers used in aerial surveys.

Additional information on fall and spring movements of unmarked Canada geese in northern Ontario were tabulated from data obtained by a cooperative reporting network established by the Ontario Ministry of Natural Resources. Agency personnel in over 30 locations throughout central and northern Ontario reported numbers of migrating Canada geese observed between mid-March and mid-June 1984-86 and September-October 1985-87. Distributions of unmarked geese were also monitored at a standardized set of important refuges and management areas October-January 1984-88 via weekly counts conducted in southern Wisconsin by personnel of the Wisconsin Department of Natural Resources (WDNR) and Horicon NWR, and by the Illinois Department of Conservation (IDOC) in Illinois (Unpubl. Canada goose inventory reps., WDNR and IDOC).

RESULTS

Spring Migration

Radio-marked geese used a fairly narrow migration corridor from southern Illinois through Wisconsin (Fig. 1). Over 98% of locations of spring migrants were between the lower Illinois River Valley and the big bend of the Wisconsin River on the west, and Lake Shelbyville and the west coast of Lake Michigan on the east. Despite biweekly aerial searches February-April 1984-86, only 1

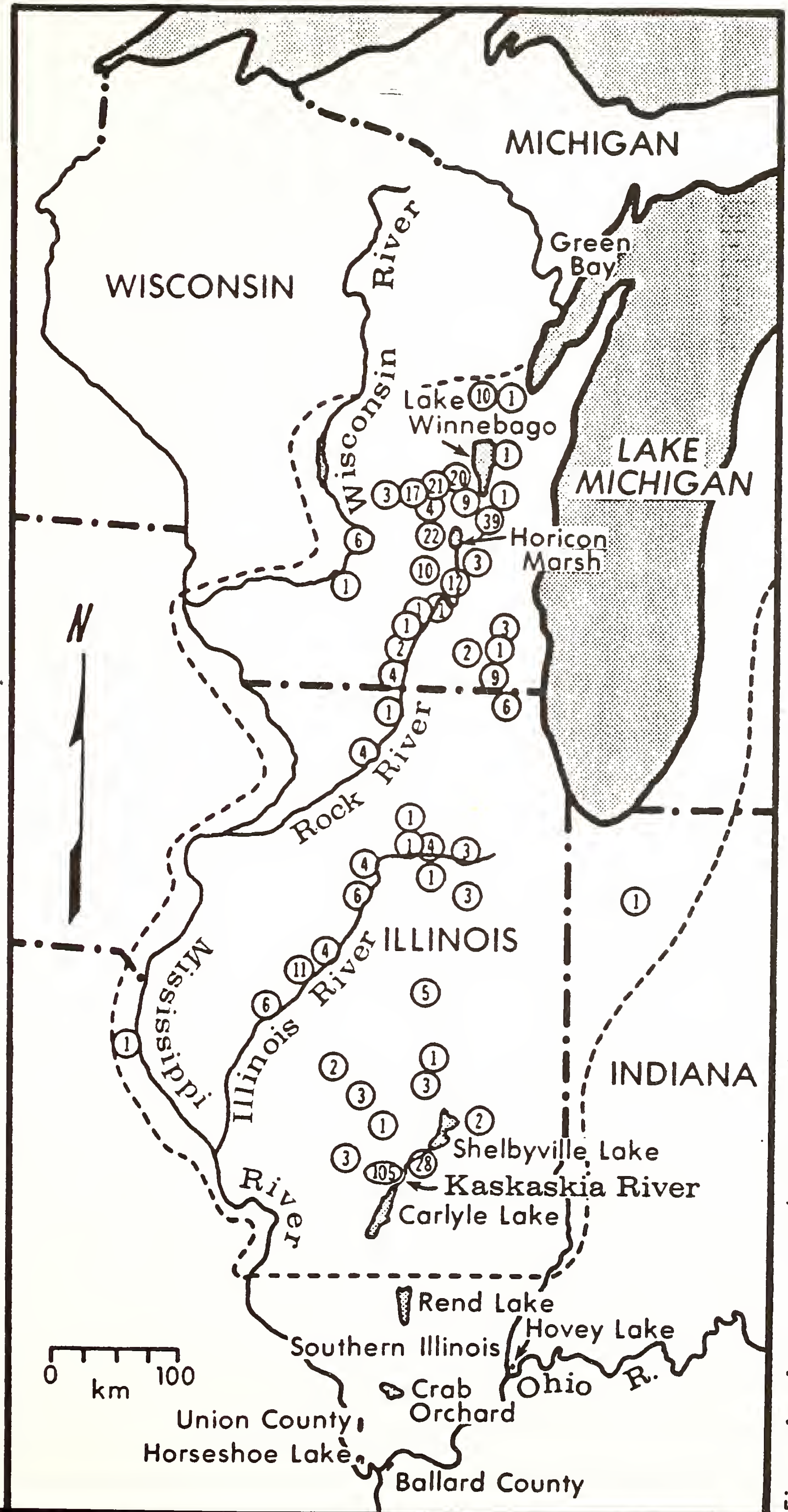

Figure 1. Area surveyed (dashed line) and locations and numbers of radio-marked Canada geese found during spring migration 1984-86.

bird was located west of the Illinois or Rock River valleys, only 1 bird in Indiana, and none in western Michigan.

Within this spring migration corridor, locations were highly associated with the Kaskaskia River Valley between Carlyle and Shelbyville lakes, the Illinois River Valley, and the Rock River Valley in Wisconsin (Fig. 1). The Kaskaskia River Valley between Carlyle Lake and Lake Shelbyville received more use by radioed geese than any other equivalent length of river valley, or any lake or marsh surveyed.

Use of the Kaskaskia River bottoms between Carlyle and Shelbyville lakes was documented in greater detail during 1986 and 1987. A minimum of 24 of 70 (34%) radio-marked birds used this area in 1986. Assuming movements of the radio-marked sample represented the estimated 500,000 geese of the MVP wintering in southern Illinois, about 170,000 birds used the area an average of at least 12 days. This represents a minimum estimate of 2.1 million goose days of use (GDU). Similar data from spring 1987 indicated 345,000 geese used the area an average of 8 days resulting in 2.75 million GDU.

Timing of departure of radioed geese from southern Illinois varied 1984-88. Initial northern movement was 4-6 February in 1984, 23-25 February in 1985, 16-20 January in 1986, and 1-4 February in 1987 and 1988. Major movement (>25% of radioed birds) was 13-17 February in 1984, 1-4 March in 1985, 20-25 February in 1986, and 15-20 February in 1987 and 1988. Peak use of rivers and lakes in central and northern Illinois was in the last week of February in 1984, and the second week of March in 1985 and 1986 (Table 1).

Most (> 50%) geese arrived in Wisconsin 7-11 March in 1984, and 14-19 March in 1985 and 1986 (Table 1). These geese gradually moved from southeastern to east-central Wisconsin in April. Major movements out of Wisconsin were 17-21 April 1984-86 (Pers. Comm., W. E. Wheeler).

First arrivals of geese in Ontario were in late March 1984-86 (Table 2); peak migration of geese was not until 22-30 April in 1984, 19-21 April in 1985, or 10-21 April in 1986. First arrivals at nesting areas near Winisk, Ontario were 2 April in 1984 and 13 April in 1985 and 1986 (Pers. Comm., J. G. Koostachin). Peak arrival near Winisk was 17-22 April all three years.

The average time geese spent during spring migration in central and northern Illinois, and in Wisconsin, varied year to year. Geese spent about 16 days in central and northern Illinois in 1984, only 4-5 days in 1985, and 18 days in 1986. Time spent in Wisconsin varied from about 48 days in 1984, to 42 days in 1985, to 35 days in 1986. Average elapsed time between departure from southern Illinois and arrival on nesting areas in Ontario varied from about 64 days in 1984, to 47 days in 1985, to 53 days in 1986.

Fall Migration

Thirty-two of 39 (82%) brooding females marked on the coast of Hudson Bay in Ontario during July 1986 were relocated in September to determine if geese of the MVP begin fall migration by gathering in staging areas on the breeding grounds. All birds but 1 (97%) were relocated within 20km (reasonable brood rearing range) of their banding sites; 1 bird moved 120 km.

Geese leaving breeding areas migrated primarily to eastern Wisconsin and southern Illinois; no radio-marked birds were found in the western lower peninsula of Michigan during October-November surveys. Data from Wisconsin weekly aerial counts indicate 38-64% ($\bar{x}$=45%) of geese counted in Wisconsin 1984-87 stayed at Horicon Marsh, while another 12-26% ($\bar{x}$=15%) stayed at Grand River Marsh. Thus, an average 60% of geese fall-staging in Wisconsin were at Horicon and Grand River marshes; the other 40% were scattered among many smaller state and federal refuge and management areas (see Craven et al. 1986).

Table 1. Chronology of spring migration through Illinois and Wisconsin of radio-marked Canada geese from the Mississippi Valley Population. Data reflect the percentage distribution of geese among regions within approximate 4-day interfals during January-April, 1984-86.

		Region searched[a]				
Dates/ year	No. radios located	Southern Illinois	Central Illinois	Illinois River	Southeastern Wisconsin	East-central Wisconsin
Jan 20-24						
1984	44	100				
1985	78	100	0			
1986	75	92	8	0		
Jan 26-28						
1984	36	100				
1985	79	100	0			
1986	66	94	6	0		
Feb 6-7						
1984	33	88	12			
1985	79	100	0			
1986	54	91	8			
Feb 11-13						
1984	26	85	15			
1985	81	100				
1986	70	86	14	0		
Feb 17-18						
1984	15	73	27			
1985	83	100	0			
1986	69	87	13	0		
Feb 20-25						
1984	16	44	44	12		
1985	51	96	4	0		
1986	66	58	42	0		
Mar 1-5						
1984	12	58	17	25		
1985	34	71	29	0		
1986	59	32	53	15	0	
Mar 7-11						
1984	13	31	8	8	53	
1985	34	38	41	6	9	6
1986	57	19	44	26	11	0

Table 1. Continued.

Dates/ year	No. radios located	Southern Illinois	Central Illinois	Illinois River	Southeastern Wisconsin	East-central Wisconsin
		Region searched[a]				
Mar 14-19						
1984						
1985	30	33	13	3	28	23
1986	59	3	10	10	67	10
Mar 22-27						
1984	13	31	0	8	61	0
1985	32	6	13	3	19	59
1986	62	3	3	0	67	27
Apr 4-6						
1984	12	0	0	0	50	50
1985	25	0	0	0	24	76
1986	0	0				
Apr 12-18						
1984	12	0	0	0	42	58
1985	19	0	0	0	10	90
1986						

[a]See text and Fig. 1 for definitions of regions. This table does not include radios located during spring migration in northwestern Illinois on the Mississippi (_n_=1) and Rock rivers (_n_=5), in extreme northeastern Illinois (_n_=6), or in northwestern Indiana (_n_=1). Blank spaces indicate regions that were not searched, while 0 indicates region was searched but no radios were located.

Table 2. Summary of reports and numbers of migrating Canada geese observed in northern Ontario[a] during spring 1984-86.

Month/ days	1984 No. reports	1984 No. geese	1984 Geese/ report	1985 No. reports	1985 No. geese	1985 Geese/ report	1986 No. reports	1986 No. geese	1986 Geese/ report
Mar									
21-31				5	27	5	6	41	7
Apr									
1-3				16	102	6	22	786	36
4-6	2	10	5	2	19	10	17	672	40
7-9	1	50	50	17	556	33	21	578	28
10-12	1	50	50	21	570	27	27	2,912	108
13-15	2	100	50	36	2,776	77	94	13,257	141
16-18				71	8,632	122	55	7,221	131
19-21	1	50	50	92	19,477	212	57	7,665	134
22-24	2	600	300	72	5,708	79	22	5,092	231
25-27				25	2,292	92	32	2,989	93
28-30	2	2,000	1,000	35	954	27	25	1,830	73
May									
1-15	1	50	50	36	700	19	37	735	20
15-31	1	50	50	20	877	44	27	684	25
Jun									
1-16				12	375	31	15	366	24

[a] Northern Ontario includes Northeastern, Northern, Northwestern, and North Central regions of the Ontario Ministry of Natural Resources.

Geese arriving in southern Illinois in mid-October 1984-87 were highly concentrated, with 72-77% of birds at Crab Orchard and Horseshoe Lake refuges (Table 3). In contrast, late migrants arriving in southern Illinois in December and January were distributed more evenly among refuges, with an average 29% at Crab Orchard, 26% at Rend Lake, 17% at Union County, and 10% at Horseshoe Lake (Table 4).

Chronology of fall migration began with geese departing the Ontario breeding grounds in September and October (Table 5). Peak departures from northern Ontario were 23 September-6 October and 15-31 October in 1985, 7-22 September and 23-31 October in 1986, and 7-22 September in 1987.

Geese began arriving in Wisconsin in mid-September 1984-87 (Pers. Comm., W. E. Wheeler), and numbers increased through early November each year (Table 6). Peak counts were 15-21 December in 1984, 3-9 November in 1985 and 1987, and 10-16 November in 1986.

Early migrants began arriving in southern Illinois in late September 1984-87, and numbers increased through early November (Table 6). Peak November counts in southern Illinois (prior to arrival of late migrants) varied from 86,000 in 1985 to 128,000 in 1987. In contrast, peak November counts in Wisconsin ranged from 187,000 in 1984 to 452,000 in 1987.

Radio-marked late migrants began arriving in southern Illinois 7-14 December in 1984 and 1987, and 1-6 December in 1985 and 1986 (Table 7). Only 25% had arrived by 22 December in 1984, in contrast to 96% in 1985, 79% in 1986, and 60% in 1987. Major winter increases in numbers of geese counted in southern Illinois were first noted 8-14 December in 1985 and 1986, and 15-21 December in 1987 (Table 6). These numbers were consistent with arrival of radio-marked birds (Table 7), and declines in numbers counted in Wisconsin (Table 6).

Table 3. Distribution of Canada geese among refuges in the southern Illinois area during October 13-15 (early migrants), 1984-87. Data are derived from Illinois Department of Conservation aerial surveys and indicate percentage distributions within years.

	Year				
	1984	1985	1986	1987	
Location	(N=49,150)	(N=59,200)	(N=88,700)	(N=88,500)	Mean
Crab Orchard	41	42	47	52	45
Horseshoe Lake	31	34	30	23	30
Rend Lake	4	4	2	6	4
Union County	18	14	17	14	16
Ballard County[a]	5	3	3	3	3
Other[b]	1	3	1	2	2

[a] Ballard County refuge is located in extreme northwestern Kentucky.

[b] Other locations include small ponds, reservoirs, and strip-mine lakes in southern Illinois.

Table 4. Distribution of radio-marked Canada geese arriving at southern Illinois area refuges in December and January (late migrants) from 1984-85 to 1987-88. Data indicate percentage distributions within years.

	Year				
	1984-85	1985-86	1986-87	1987-88	
Location	(n=12)	(n=22)	(n=14)	(n=18)	Mean
Crab Orchard	33	27	29	28	29
Horseshoe Lake	0	14	21	6	10
Rend Lake	33	27	21	22	26
Union County	8	14	21	22	17
Ballard County[a]	8	9	0	16	8
Other[b]	18	9	8	6	10

[a] Ballard County refuge is located in extreme northwestern Kentucky.

[b] Other locations include reservoirs and strip-mine lakes in southern Illinois, and Hovey Lake Wildlife Management area in southern Indiana.

Table 5. Summary of reports and numbers of migrating Canada geese observed in northern Ontario[a] during fall 1985-87.

Month/ days	1985 No. reports	1985 No. geese	1985 Geese/ report	1986 No. reports	1986 No. geese	1986 Geese/ report	1987 No. reports	1987 No. geese	1987 Geese/ report
Aug									
15-22	4	0	0	4	19	5	3	17	5
23-31	5	225	45	5	45	9	0	0	0
Sep									
1-6	13	344	26	4	93	23	5	168	34
7-14	41	1,399	34	49	6.186	126	12	442	37
15-22	22	1,111	51	61	6,008	68	64	6,196	97
23-30	24	2,653	111	51	3,471	68	17	1,091	64
Oct									
1-6	16	1,730	108	25	1,632	65	14	402	29
7-14	10	367	37	14	328	23	8	384	48
15-22	19	3,417	180	14	257	18	3	8	3
23-31	7	1,490	213	8	1,115	139	1	0	0
Nov									
1-16	8	181	23	8	38	5	0	0	0

[a] Northern Ontario includes Northeastern, Northern, Northwestern, and North Central regions of the Ontario Ministry of Natural Resources.

Table 6. Numbers of Canada geese (thousands) counted during weekly aerial surveys in Illinois and Wisconsin from October-January, 1984-85 to 1987-88.

Month/ days[a]	1984-85				1985-86				1986-87				1987-88			
	South. Ill.	Upper Ill.	East. Wis.	Total	South. Ill.	Upper Ill.	East. Wis.	Total	South. Ill.	Upper Ill.	East. Wis.	Total	South. Ill.	Upper Ill.	East Wis.	Total
Oct																
4-11			87	87			74	74			202	202			208	208
12-18	49		130	179	59	56	213	328	89		176	265	89	53	271	413
19-25	90		169	259			254		104	22	184	310	107	39	295	441
26-2	94	28	184	306	75	67	224	366	81	31	204	316	111	62	304	477
Nov																
3-9	111	25	155	291	86	45	378	509	101	27	226	354	114	42	452	608
10-16	101	14	177	292					91	30	274	395	128	63	388	579
17-23	96	11			70	120	206	396			252		121	63	359	520
24-30	94	11	187	292			176		96	30			136	43		
Dec																
1-7	90	16	201	307	167	88					184		148		250	398
8-14*	133	10			355	160	17	532	201	26	125	352	156	89	269	514
15-21			257						327		42	369	522		122	644
22-28									331				499			
29-5									302	89		391	572			572
Jan																
6-12	316		28	344					203	66		269	611			611
13-19	363	4		367												
20-26	384			384					262			262	340			340

[a] Southern Illinois includes Crab Orchard, Horseshoe Lake, Rend Lake, and Union County refuges, and Campbell's Pond in Illinois, and Ballard County refuge in northwestern Kentucky; Upper Illinois includes the Mississippi River north of St. Louis, the Illinois River, and lakes in central and northern Illinois; Eastern Wisconsin includes the Wisconsin River Valley and Wisconsin east of the Wisconsin River (see Fig. 1).

[b] To facilitate analyses, some surveys included in these approximate weekly intervals were actually conducted 1-2 days before or after the indicated dates. Oct 26-2 = Oct 26-Nov 2 and Dec 29-5 = Dec 29-Jan 5.

*Mid Winter goose inventory was conducted.

Table 7. Chronology of arrival of radio-marked Canada geese in southern Illinois during December and January (late migrants) from 1984-85 to 1987-88. Data indicate percentage arriving by week within years.

Month/ days	Year 1984-85 (*n*=12)	 1985-86 (*n*=22)	 1986-87 (*n*=14)	 1987-88 (*n*=18)
Dec				
1-6	0	73	14	0
7-14	25	14	58	27
15-22	0	9	7	33
23-31	33	0	7	6
Jan				
1-6	42	4	0	17
7-14	0	0	7	11
15-22	0	0	0	6
23-31	0	0	7	0

Seasonal Homing

No association was found between segments of the MVP (defined on the basis of fall distribution) and use of specific spring staging areas, or chronology of spring migration. Overall and weekly chronology of use of the Kaskaskia River bottoms and Horicon NWR in spring did not vary ($\underline{Z}$ tests, $\underline{P} > 0.20$) between early and late fall migrants, or between birds that spent the previous fall at Crab Orchard NWR or Union County Refuge. This similarity among segments in routes and chronology of spring migration was observed within each of the study years, as well as for all years combined.

DISCUSSION AND CONCLUSIONS

Spring Migration

Over 98% of radio-marked Canada geese monitored during spring used a relatively narrow migration corridor through central Illinois and eastern Wisconsin. Assuming our marked sample was representative of the MVP, less than 1% of the birds used western Indiana or western Michigan during spring migration. Relative use of major spring staging areas in Illinois and Wisconsin and chronology of migration did not vary among segments of the MVP that spent the previous fall in Wisconsin (late migrants) or southern Illinois (early migrants), or segments that spent the previous fall at different southern Illinois refuges.

The Kaskaskia River Valley between Carlyle and Shelbyville lakes in central Illinois was used by more geese of the MVP than any other spring staging area of equivalent size. Despite an average stay of only 8-12 days, spring use of the Kaskaskia River Valley approached October-February goose use of Rend Lake (Pritchert 1988:32) and other smaller southern Illinois refuges.

Variation in amounts of time (4-18 days) geese staged in central and northern Illinois was associated with annual variation in where geese accumulated endogenous nutrient reserves for subsequent reproduction (Gates 1989). Adults of the MVP obtained 12% of lipids accumulated during spring migration prior to arrival in Wisconsin during 1985 (4-5 days in central and northern Illinois), and 22% in 1986 (18 days in central and northern Illinois). This association emphasizes the potential importance of spring staging areas in Illinois in providing adequate quality and quantity of foods.

Average dates of departure from Wisconsin, migration through northern Ontario, and arrival in Winisk suggest that most geese moved rapidly from Wisconsin to nesting areas in Ontario each year. Overlapping peak migration dates, and the concentration of observations around these peak dates, suggest few geese took more than 2-3 days to migrate from Wisconsin to nesting areas in Ontario.

Fall Migration

Canada geese of the MVP did not move from scattered nesting areas to fall staging areas in northern Ontario, but apparently migrated to fall use areas in southeastern Wisconsin or southern Illinois using essentially the same corridor (reverse direction) as in spring. Fall staging in Wisconsin was highly concentrated at Horicon and Grand River marshes, while early migrants to southern Illinois concentrated at Crab Orchard and Horseshoe Lake refuges. After leaving Wisconsin, late migrants were more evenly distributed among southern Illinois refuges than early migrants. Observations of distribution of early and late migrants in southern Illinois differed substantially from those of Kennedy and Arthur (1974).

A strong trend has emerged for more geese to fall stage in Wisconsin. The MVP increased from about 300,000 to over 500,000 during this study, while the number of birds fall-staging in southern Illinois remained under 130,000. In contrast, numbers fall staging in Wisconsin increased by nearly 200,000; the percentage of total geese counted in Illinois and Wisconsin during fall that staged in Wisconsin increased from about 50% in 1984 to nearly 80% in 1987.

These recent changes in fall distribution of the MVP have been associated with both harvest and habitat conditions. Increasing goose day use (GDU) in southern Wisconsin has required restriction of daily bag limits to control harvest within annual objectives (Unpubl. Reps., Mississippi Flyway Council), leading to reduced harvest relative to GDU. The plethora of geese and limited harvest in Wisconsin has resulted in hunters having little impact on daily activities, allowing geese roosting on refuges to exploit surrounding private lands for food (Caithamer 1989). Virtually unlimited access to food, and concentration of high energy food sources (corn), allowed late migrants in Wisconsin to rapidly deposit pre-winter lipid reserves that were nearly double those of early migrants (Gates 1989) that are restricted by intense hunting pressure to refuge areas during the southern Illinois hunting season (Caithamer 1989). Easy access to private lands and increasing fall GDU have also resulted in substantial increases in crop depredation complaints in southeastern Wisconsin (Unpubl. Reps., Wisconsin Dep. Natur. Resourc.).

The annual midwinter inventory of the MVP is unreliable because it is usually conducted during movement of late migrants to southern Illinois. The midwinter inventory was conducted the second week (8-14) of December 1984-87. Peak combined counts for Illinois and Wisconsin were 20-26 January in 1984, 8-14 December in 1985, 10-16 November in 1986, and 15-21 December in 1987. In 1986, peak combined counts exceeded midwinter inventory counts by 12%. In 1987, the difference was 25%. Radio-marked geese were in-transit from Wisconsin to Illinois 7-14 December in all 4 years; telemetry data suggest at least 14% (1985) to 58% (1986) of geese could have been missed by the midwinter inventory because birds were scattered or in flight. Chronology data suggest the MVP is most concentrated in either the second week of November (after most geese have arrived from Ontario) or the second week of January (after arrival of late migrants in southern Illinois and before spring migration). The current midwinter inventory not only consistently underestimates the MVP (inaccurate), but the degree of underestimation is sufficiently variable (imprecise) to make these counts unreliable as an index.

MANAGEMENT RECOMMENDATIONS

Appropriate private, state, and/or federal agencies should continue to protect and/or enhance roost and feeding habitat for spring migrating geese at major staging areas in Illinois and Wisconsin. The Kaskaskia River Valley between Carlyle and Shelbyville lakes in Illinois is virtually unprotected and unmanaged; improvements should concentrate on the area between the Carlyle Lake subimpoundments and the city of Vandalia (see Moser and Tacha 1988).

The midwinter inventory of the MVP should be conducted in the second week of January when fall migration is complete and birds are most concentrated. Current inventories conducted mid-December are too inaccurate and imprecise to serve as reliable population estimates, or an index.

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Job VI. Role of southern Illinois refuges in contributing needs of Canada geese September-March

Objective: Provide a better understanding of actual and/or potential contribution of each refuge in Illinois and adjacent states with special emphasis on the southern Illinois region as evidenced by goose utilization.

INTRODUCTION

Following are abstracts summarizing findings for this Job and recommendations for application of findings to Canada goose management in southern Illinois and other locations. Two Ph.D. dissertations are appended to this report in lieu of a Job VI Completion Report.

ABSTRACTS

Habitat Use and Time and Energy

Habitat and refuge use of wintering and migrating Mississippi Valley Population (MVP) Canada geese (*Branta canadensis interior*) were studied October-February 1984-1987 at Union County Conservation Area (CA) and Rend Lake in southern Illinois and October-December and March-April 1984-1986 at Horicon National Wildlife Refuge (NWR) in Wisconsin. Habitat and refuge use were quantified by driving survey routes representative of available habitats. Use of refuges increased ($P < 0.05$) during hunting seasons at southern Illinois study areas, but did not ($P = 0.16$) at Horicon NWR. Habitat use varied among seasons and locations. Use of winter wheat and alfalfa/clover habitats was highest ($P < 0.05$) in fall, use of lakes was highest ($P < 0.05$) in winter, and use of lowland pastures was highest ($P < 0.05$) in spring. Shallow wetlands and corn fields were used more ($P < 0.05$) at Horicon NWR,

while winter wheat and soybean fields were used more ($P < 0.05$) at southern Illinois study areas.

Estimates of time and energy allocations for populations at Union County CA and Horicon NWR were developed from activity estimates of flocks observed during habitat use surveys. Total energy available on and within 16 km of both refuges was estimated from land use inventories and food sampling within agricultural habitats. Activities varied ($P < 0.05$) among habitats. Resting was the most common ($P < 0.05$) activity on lakes and feeding was most common ($P < 0.05$) in upland habitats. Energy needs ranged from 509-926 kcal/goose/day. Available energy resources did not appear adequate on Union County Refuge during hunting season in 1 of 3 years. Adequate energy was available during all seasons within 16 km of both refuges.

Diurnal time budgets of parent males and females, paired males and females, unpaired adults, and juveniles were estimated for geese at Union County CA and Horicon NWR. Parents consistently spent more ($P < 0.05$) time alert than pairs. During fall, parent males sacrificed time resting and parent females sacrificed time feeding to maintain vigilance. Parental vigilance probably allowed juveniles to feed extensively.

Time budgets of breeding males, breeding females, and non-breeding adults were estimated during prelaying through postfledging periods on the MVP breeding grounds near Winisk, Ontario. Breeding males spent more ($P < 0.05$) time alert than their mates, allowing females to feed extensively before nesting and maintain high nest attentiveness during incubation. Costs of parental care were shared more or less equally between sexes on an annual basis.

Physiological Condition and Nutrition

Temporal, spatial, and social variation in body composition and nutrition of Mississippi Valley Population (MVP) Canada geese (Branta canadensis interior) were studied July 1984-February 1987 in southern Illinois, east-central Wisconsin, and northern Ontario. Diet composition and food intake requirements were estimated, and the relative importance of endogenous vs. exogenous nutrients in meeting seasonal nutritional demands was determined.

Geese deposited lipid and protein during October-December; these reserves were partially catabolized during December-February. Geese spending fall in Wisconsin (late migrants) deposited and catabolized more lipid between October and February than geese spending fall in southern Illinois (early migrants). Differences in body composition between early and late migrants were related to diet composition and environmental conditions encountered in fall. High corn consumption in Wisconsin was associated with lipid, but not protein, deposition by late migrants. Hunting in southern Illinois restricted access by geese to corn in November. Early migrants consumed mostly forage and deposited less lipid, but more protein during fall than late migrants. Late winter lipid catabolism was not obligatory, depending instead on the size of lipid reserves acquired in fall, and winter weather and feeding conditions.

Large lipid and protein reserves were deposited during March-April as geese increased daily dry mass intake of diverse, moderate energy diets. Spring lipid reserves were used to complete spring migration and during long prenesting intervals (28 days). Food intake before nest initiation was essential to conserve endogenous nutrient reserves for egg formation and incubation. Endogenous reserves supplied all of the lipids incorporated into eggs, but exogenous protein and minerals contributed partially to egg formation. Lipid and protein reserves mobilized during nesting were replenished before fall migration. Food intake was adequate to supply gross energy and protein requirements during wing and body-molt.

Geese <2 years old were physically immature, having smaller skeletal sizes and protein and muscle masses than older geese. Parent females maintained smaller lipid masses than non-parent paired females during December-March. Lipid masses of non-parent paired males increased more than those of parent males during March-April. Paired females deposited more lipid than unpaired females in spring, and paired geese retained more lipid than unpaired geese before nest initiation.

RECOMMENDATIONS

Habitat Use and Time and Energy

The following management recommendations are intended to assist resource management in meeting the needs of Canada geese at Union County CA, Rend Lake, and Horicon NWR. Recommendations assume populations at each area will remain similar to those observed in this study. Efficient use of available land would be more critical with higher populations.

Southern Illinois Refuges. - Habitat management on Union County CA and Rend Lake Refuge has large potential for affecting geese because refuge use was consistently high. Lake, shallow wetland, and alfalfa/clover habitats should be developed and/or increased on Union County CA and Rend Lake Refuge.

Soybean habitat was abundant on private land and need not be made available to geese on Union County CA or Rend Lake Refuge. However, soybeans are valuable for agricultural field management (Johnson grass [Sorghum halepense] control and nitrogen fixation [D. D. Nance pers. comm.]), and are suitable to precede a second crop of winter wheat.

Union County CA should continue to provide 260-315 ha of corn when approximately 20% of private agricultural land is devoted to corn. This amount of corn should be adequate when goose populations at Union County CA are similar to levels observed during this study. Pritchert (1988) recommended increasing availability of corn on Rend Lake Refuge.

Winter wheat and other forage (mostly fescue) availability on Union County CA and Rend Lake Refuge should remain at levels observed during this study. These forage foods provide nutrients not supplied by corn.

Sunflowers need not be grown specifically for geese as recommended by Hanson (1962) to provide a good source with high concentrations of methionine and cystine. Geese apparently met these amino acid requirements from other foods as sunflower fields (other crop habitat) had little use in all years and low selection in one year. Joyner et al. (1987) suggested increased ingestion rates could compensate for amino acid deficiencies in cereal grains. If sunflowers are desired, fields can be managed to produce a double-crop of sunflowers followed by winter wheat.

Milo probably will continue to be adequately available on private lands and should not be emphasized when managing for geese at Union County CA or Rend Lake. Milo had low use in this study while others (Sauer 1983, Paine 1985, Pritchert 1988) documented both low use and low selection at southern Illinois refuges.

Energy availability should meet or exceed population energy needs if a management goal is to maintain geese in the best possible condition. Restriction of geese to Union County Refuge during hunting season increases the potential impact of inadequate energy availability on the refuge during hunting. There are at least 2 basic alternatives to increase the availability of energy during hunting. The first alternative emphasizes reducing goose restriction to the refuge, and the second alternative emphasizes increasing energy availability on-refuge.

Reducing hunting pressure adjacent to refuge boundaries would likely increase off-refuge energy exploitation, but this requires further study. Further restriction of local hunting opportunity may be politically unpopular but biologically appropriate. More frequent periods of no hunting pressure could be provided by 1) closing hunting earlier each day (currently closes at 1500), 2) closing hunting ≥ 1 day per week, or 3) splitting the season with a 2-3 week period of no hunting. Reduced hunting intensity near refuge boundaries could also be achieved by increasing the minimum distance between blinds or redistributing hunters over a larger area with a mandatory permit system (similar to Wisconsin's system).

The timing of hunting season influences population energy needs during hunting. Long seasons lead to greater goose-day-use and energy needs than short seasons. Seasons which continue after arrival of late migrants lead to higher average daily population sizes and energy needs than seasons ending before arrival of late migrants. The least energetically demanding season would be short and early, but this could lead to difficulties in meeting harvest objectives (see Paine and Tacha 1987). Increasing the daily bag limit above the current 2 geese per day would likely increase the average daily kill and thus permit a shorter season while still meeting harvest objectives.

Energy available on-refuge could be increased by expanding the size of agricultural habitats available or by altering crop management. More agricultural habitats could be produced through conversion of forest habitat to agricultural habitat or through land acquisition. Both options may not be desirable because of initial expense. Also, bottomland hardwood forests are important to other waterfowl populations and have been identified as a habitat needing special protection (U.S. Fish and Wildl. Serv. and Can. Wildl. Serv. 1986). The most politically and economically promising strategy to increase energy availability may be to alter crop management.

Maximum energy resources can be provided during hunting season by harvesting more corn during this period. However, an increase in the proportion of corn fields combined causes a decrease in the proportion that can be mowed after hunting. Since mowing makes more food available than combining, the net result of increased combining is lower energy available after hunting. The effect of reduced energy available after hunting is unknown; geese may 1) compensate by exploiting more off-refuge resources, 2) disperse to other areas, and/or 3) reduce energy intake.

The timing of crop harvest affects energy available during hunting. Combining too early causes risk that fields will be completely gleaned of food before the start of hunting. Harvest should be continued at intervals as needed during the entire hunting season to continually provide high energy grain. The area combined should increase as the season progresses to meet the increasing needs caused by the larger population after arrival of late migrants. Details on the optimal timing of crop harvest require further investigation.

Horicon NWR and Wisconsin. - Horicon NWR should continue to emphasize wetland management. Shallow wetland habitat was important but may be inadequately available in the Horicon NWR area. State or federal agencies should consider measures to protect small wetlands and associated lowland pastures to the north and west of Horicon NWR. These habitat complexes were important in Spring when geese acquired body reserves important for reproduction (Gates 1989).

Agricultural habitat currently need not be developed on Horicon NWR. All important agricultural habitats were adequately available on private land. However, extensive fall plowing should be actively discouraged when possible.

Dairy farming should be encouraged near Horicon NWR. Resource availability near Horicon NWR is strongly affected by dairy farming. Lowland pasture, alfalfa, high moisture corn, and spread manure are all components of dairy farming and also important to geese. Reduction in dairy farming could negatively impact goose resources (Hunt and Hanson 1975).

Consistent estimates of excess energy availability, and body mass and lipid mass gains by geese (Gates 1989), suggest the Horicon NWR area has enough energy resources to support a larger fall population than was observed in 1984 and 1985. Large gains in body reserve made during Spring (Gates 1989) also indicate adequate or excess energy was available. In terms of energy availability, the Horicon NWR area may be able to support a larger population in Spring, but this requires further study. However, increasing fall goose-use in Horicon NWR area could result in unacceptable levels of crop depredations (see Craven et al. 1985).

Physiological Condition and Nutrition

Physiological condition and diets of MVP geese were highly interrelated. Since diet composition was primarily influenced by availability and access to agricultural crops, the potential exists to manipulate body composition through crop management. Emphasis on providing high energy foods (such as corn) should promote lipid deposition during early fall, allowing geese to rely more on stored reserves during hunting season and in winter.

The ability of waterfowl to maintain energy balance at low temperatures is an important factor influencing their northern limit of distribution during winter (LeFebvre and Raveling 1967, Caine 1973, Prince 1979). Increased cropping of high energy grains and hydrological changes outside traditional wintering areas has allowed many species of waterfowl to expand their winter ranges northward (Chabreck 1979; Bellrose 1981; Jorde et al. 1983, 1984; Alisauskas et al. 1988). Similar trends were evident among MVP Canada geese as increasing proportions of the population have recently remained in east-central Wisconsin during most of fall before migrating to southern winter refuges. Additional research is needed to evaluate factors influencing latitudinal distribution of MVP geese in fall. Results of this study and Caithamer (1989) suggest that geographic differences in hunting pressure and food availability on refuge and private lands are involved via effects on fall energy balance and nutrient deposition.

Deposition of large lipid reserves by geese on high energy-low protein diets in east-central Wisconsin may not have been entirely advantageous if protein deposition was compromised. The value of lipid reserves as a source of energy is obvious; however, the biological significance of reducing diet and carcass protein levels requires further examination. Protein is an important constituent of locomotor organs; late migrants had smaller crus wet masses than early migrants in November and December and smaller breast wet masses prior to spring migration in February. Sub-adult ($\leq$2 years) geese had not attained the muscle masses of older geese, possibly influencing their pairing status. MVP geese were also completing body-molt during October-December, likely causing increased daily protein requirements (Heitmeyer 1988b). Like other animals, birds have daily maintenance requirements for protein and essential amino acids that may be supplied by mobilizing body tissue if food intake is inadequate. Endogenous protein may also be catabolized to provide energy during fasts (Fisher 1972, Hazelwood 1972, Griminger 1976, Robbins 1983). This and other studies have documented the simultaneous catabolism of lipids and protein by wintering waterfowl (Hanson 1962a, Peterson and Ellarson 1979, Reinecke et al. 1982).

The importance of diet quality in goose nutrition requires consideration in both management and research. Research is needed to identify specific micronutrient requirements (essential amino and fatty acids, vitamins and minerals) and sources for wild geese. Corn is a less balanced source of micronutrients that are supplied more adequately by other grains, forages, and wild seeds (Maynard et al. 1979, Baldassarre et al. 1983, Heitmeyer 1985). Until micronutrient requirements are better known, it would be prudent for managers to provide a diversity of food types to wintering geese. High energy foods should be balanced with those that supply protein and other nutrients as well. Alternate grain crops such as soybeans and sunflowers, or moist soil management (Fredrickson and Taylor 1982) could improve diet quality at intermediate levels of energy.

Soybeans have been eliminated from southern Illinois refuges when geese are present (D. D. Thornburg, pers. comm.) over concern for potential die-offs due to esophageal impaction (Jarvis 1976). Aerial seeding of winter wheat in soybean fields prior to harvest at UCCA in the first 2 years of this study appeared to be an effective means of minimizing the risk of impaction. Geese consumed large proportions of wheat leaves in soybean/wheat fields, even shortly after soybeans were harvested. Although soybeans comprised up to 67% of goose diets in some seasons, no evidence of mortality due to soybean impaction was observed. Retaining soybean stubble in fields double-cropped with wheat on goose refuges would maximize food availability on limited acreage, provide geese with an additional moderate energy and high protein food source, and solve problems associated with current crop rotations on state refuges (D. D. Nance, pers. comm.).

Nutritional needs during hunting season in southern Illinois require special attention from managers since geese obtained nearly all of their food from refuge lands during this time (Caithamer 1989). Unless adequate quantities of high energy foods are supplied at UCCA during hunting, fall lipid deposition by early migrants may be impeded or reversed. This will be an increasing concern if fall goose-day-use increases in response to population increases and/or longer hunting seasons. Unfortunately, providing large quantities of high energy foods during hunting may be inconsistent with goose harvest goals. An alternative is to encourage lipid and protein deposition through provision of high energy grains and/or more nutritionally balanced forages and moist soil foods before hunting season. Diet quality can be further emphasized during hunting while energy sufficient to meet only maintenance requirements is provided. Geese should enter winter with sufficient lipid reserves to sustain them during the most severe winter weather.

Results of this study can be used to project energy requirements of MVP geese wintering in southern Illinois, and to help design optimum refuge cropping strategies. Depending on season, an average of 524 ± 38(SD) kcal/goose AME must be provided daily to maintain geese with no change in body condition after arrival on refuges in October. Additional energy must be provided to ensure that geese enter winter with adequate lipid reserves. During this study, which included average to severe winter weather but above-average crop yields, December lipid masses of 490-650 g were more than sufficient to ensure that geese left southern Illinois with larger lipid reserves than when they arrived. Even with December lipid masses of 500-600 g, about 85% of daily energy requirements must be supplied from food during winter. Population energy requirements, estimates of food density in individual habitats, and AME values of different foods can be used to calculate areal estimates of crops required to maintain geese in a desired level of body condition.

The central hypothesis advanced from the results of this study is that larger corn:forage crop ratios should promote greater lipid deposition when food is supplied in excess of population energy requirements, but at the expense of diet quality and protein deposition. Comparisons of diet, body composition, and foraging patterns between years and between separate refuges under different crop management regimes, would further clarify nutritional strategies and tactics of wintering MVP geese. Of particular interest is the degree to which diet composition is influenced by changes in habitat availability. Additional comparisons of body composition between early and late migrants during winter as food availability varies between separate refuges and years would further define the range of nutritional tactics employed by MVP geese. MVP geese are singularly suited to such a comparative experimental approach to studying the nutritional ecology of wintering waterfowl. Migration chronology, population sizes, and distribution of MVP geese are well known, and the dependence of MVP geese on refuges in fall and winter facilitate the monitoring and manipulation of their food base.

Net gains in lipid reserves at UCCA during fall-winter represented only a small fraction of energy reserves carried by MVP geese to their nesting areas. Nearly 67% of lipid and 50% of protein reserves acquired in spring migration were obtained in 4-5 weeks near HNWR. Despite differences between years in time spent near HNWR, and lipid and protein masses at arrival near HNWR in spring, adult geese departed for nesting areas with nearly identical lipid and protein reserves each year. Nearly all of these reserves were apparently acquired at least 1-2 weeks before geese departed HNWR for nesting areas (W.

E. Wheeler, unpubl. data). This suggests an upper limit to the size of nutrient reserves that geese will transport to nesting areas in spring. If these results are typical of most years, then feeding conditions during winter and spring migration currently have little or no effect on reproduction of MVP geese. However, adequate supplies of waste corn, and a diversity of other food items that provide protein and micronutrients, must be maintained in east-central Wisconsin. Increases in goose-day-use near HNWR may leave less corn available to geese in spring. Small wetlands, moist soil areas, and low-lying bluegrass pastures where spring migrating geese obtained most of their green forages, seeds, and tubers, should be maintained in east-central Wisconsin.

Note: Literature cited in recommendations can be found in the Appendices for this Job.

Job VII. Analysis and Report

Objective: To analyze results from Jobs I through VI and prepare quarterly, annual, and final reports which summarize and discuss findings.

This objective has been met through quarterly and annual reporting of findings, and submission of Job final reports. Original data and copies of all Quarterly and Annual Federal Aid Performance Reports are on file at the Cooperative Wildlife Research Laboratory, Southern Illinois University, Carbondale, Illinois 62901.